内置自适应同步升压/AGC/限温功能
8W单声道智能音频功率放大器

■ 特点

・具有电池跟踪和限幅功能的自动增益控制（AGC）
- 电池跟踪（Battery Tracking）功能：电池电压较低时，自动减小系统增益，延长电池续航时间
- 限幅（Limiter）功能：自由选择音频限制幅度，使输出音频信号限制在固定失真水平内

・内置自适应同步升压
- 小音乐信号时不升压，可大幅提高系统效率，延长电池续航时间
- 外围无需二极管

・内置自动限温控制功能
-特别适用于升压8.0V+D类，升压+AB类状态下及环境温度较高的情况，显著提升音乐峰值功率

・静态电流：4.0mA, 3.6V
・效率：88%（V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 0.6W）
・THD+N：0.02%（V_{BAT} = 3.6V, R_L = 4Ω+22uH, Po = 0.5W, Class D）
・灵活配置：可选择硬件或I^2C控制模式
・电源
-升压输入V_{BAT}：2.8V至5.0V
-升压输出V_{POUT}多种选择：5.5V, 6.5V, 7.5V, 8.0V
・输出功率
3.4 W (V_{BAT}=4.2V, V_{POUT} = 5.5V, R_L=4Ω, THD+N=1%)
4.7 W (V_{BAT}=4.2V, V_{POUT} = 6.5V, R_L=4Ω, THD+N=1%)
6.2 W (V_{BAT}=4.2V, V_{POUT} = 7.5V, R_L=4Ω, THD+N=1%)
7.0 W (V_{BAT}=4.2V, V_{POUT} = 8.0V, R_L=4Ω, THD+N=1%)
8.5 W (V_{BAT}=4.2V, V_{POUT} = 8.0V, R_L=4Ω, THD+N=10%, instantaneous)
・二种增益选择：25dB, 30dB； I^2C控制模式下最大支持80阶音量调节
・多种模式可选：升压+D类，升压+AB类，单独D类，单独AB类
・保护功能：过流/过热/欠压异常保护功能
・无铅无卤封装，TSSOP20L-PP

■ 概述

HT862是一款内置自适应同步升压/AGC/限温功能的单声道智能音频功率放大器。由锂电池供电升压至8.0V时， 4Ω负载条件下，能连续输出7W功率（1% THD+N）；能瞬态输出8.5W的功率（10% THD+N）。

HT862内置的自适应同步升压无需外置二极管，并可提供5.5V, 6.5V, 7.5V, 8.0V四种输出电压选择，以满足不同的输出功率需求。另外，该升压还具有自适应功能，小音乐信号时不升压，可大幅提高系统效率，延长电池续航时间。

HT862内置了丰富的自动增益控制（AGC）功能，包括限幅(Limiter)和电池跟踪(Battery Tracking)功能。限幅功能开启后，即使输入信号很大，音乐输出也能被限制在指定的功率和THD+N之内；电池跟踪功能开启后，当电池电压低于设定值，HT862能随电池电压降低而逐步减小增益以限制电池电流，此举能大幅延长电池续航时间，并且能防止破音和过大的电流需求，降低电池在低电量时提前进入锁死状态的风险。

HT862还具有自动限温控制（TFB）功能，在高功率输出、高环境温度等情况下导致芯片片内温度较高时，芯片能自动降低系统增益，避免芯片进入过温关断保护模式，在保证音乐品质的前提下显著提升音乐峰值功率。

HT862可在多种模式下自由切换，以满足更多的系统应用需求：升压+D类，升压+AB类，单独D类，单独AB类。

HT862支持硬件控制模式和I^2C控制模式。在I^2C控制模式下，提供了丰富的功能和参数配置。

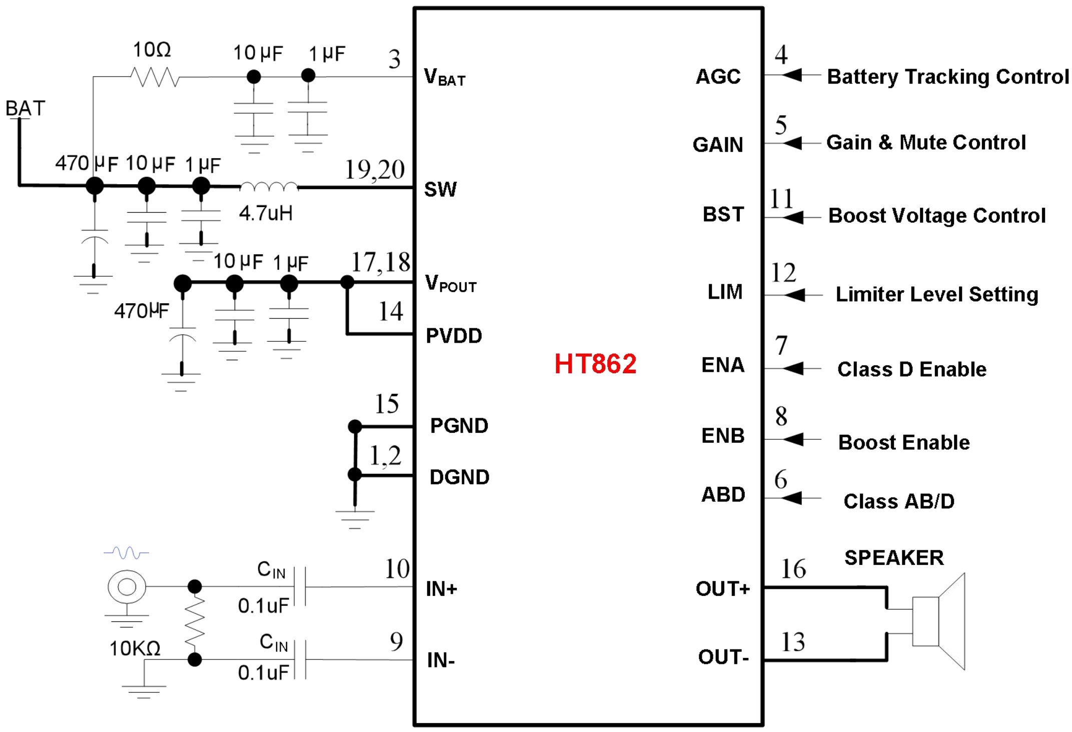
此外，HT862内部集成免滤波器调制技术，能够直接驱动扬声器，内置的关断功能使待机电流最小化，还集成了输出端过流保护、片内过温保护和电源欠压异常保护等功能。

■ 应用

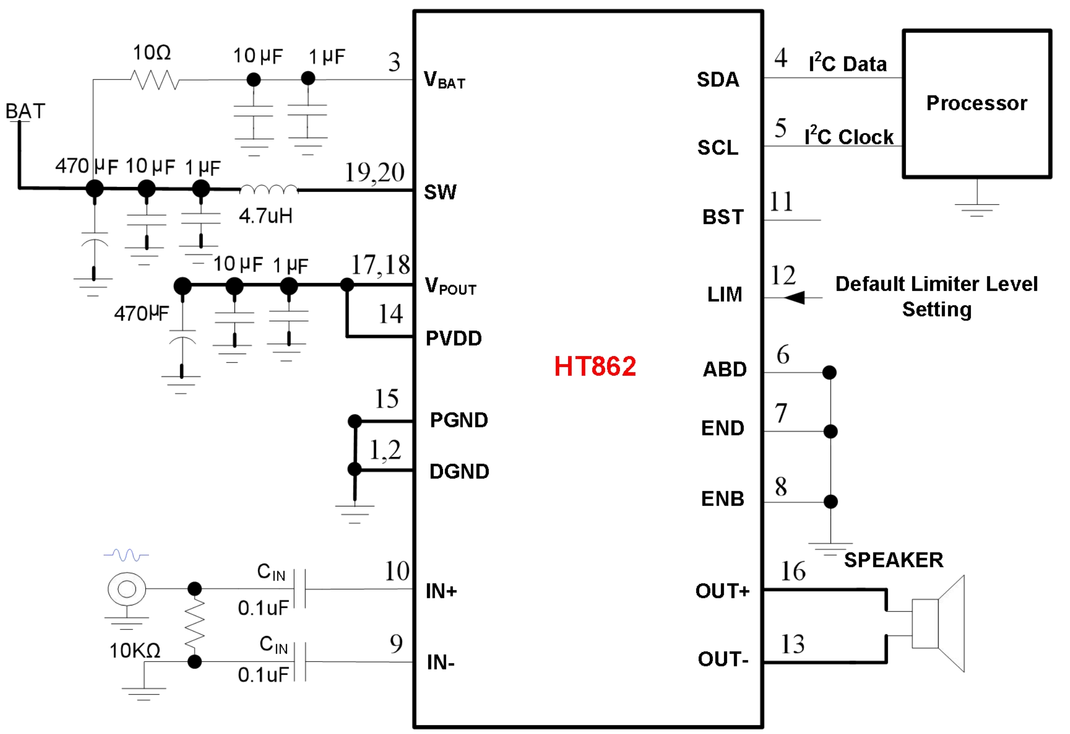
・蓝牙音箱/Wi-Fi音箱	・便携式音箱	・2.1声道小音箱	・拉杆音箱
・iphone/ipod/ipod docking	・MP4，导航仪	・平板电脑，笔记本电脑	・智能手机
・小尺寸LCD电视/监视器	・便携式游戏机		

■ 典型应用图

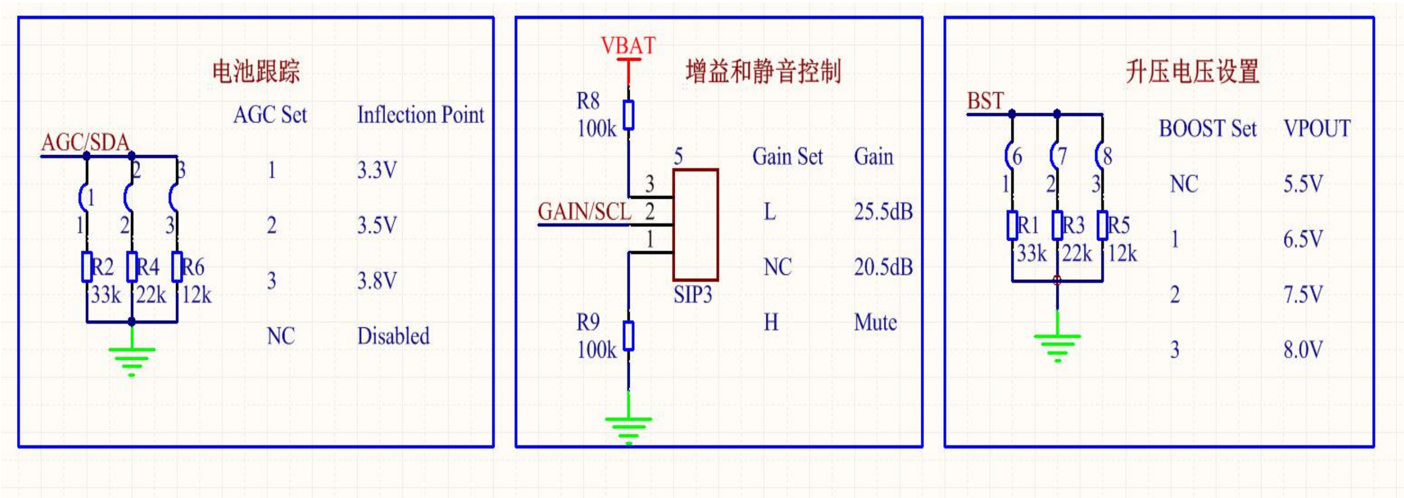
1. 硬件控制模式



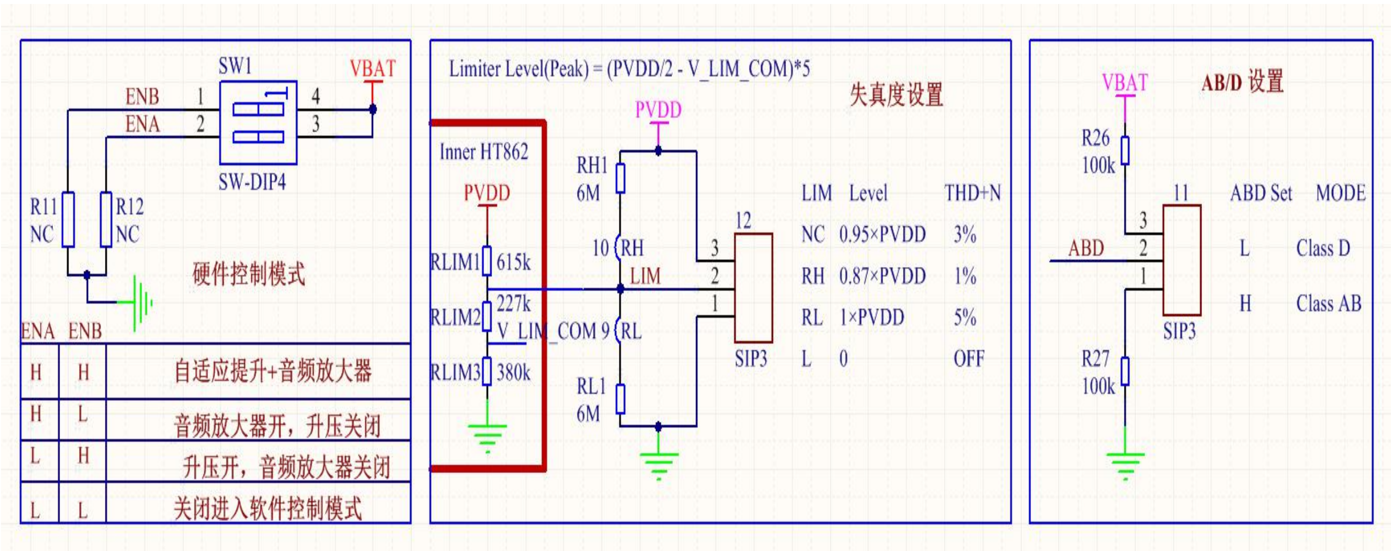
2. 软件控制模式



1,硬件控制,AGC ,GAIN ,BST。



2,硬件控制,ENA,ENB ,LIM,AB/D。



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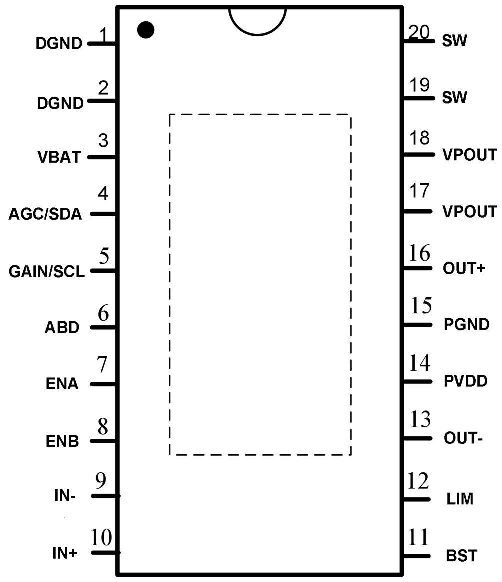
■ 引脚信息



TSSOP20L-PP 顶视图

■ 引脚定义

TSSOP 脚号	引脚名称	I/O*1	功能
1,2	DGND	GND	Boost Converter功率地
3	V_{BAT}	Power	电池电源输入端
4	AGC/SDA	I/O	AGC电池跟踪拐点设置端；当ABD = ENA = ENB = L时可作为I²C数据端口，开路输出需上拉电阻
5	GAIN/SCL	I	Audio Amplifier增益设置端，静音设置端；当ABD = ENA = ENB = L时可作为I²C时钟端口，开路输出需上拉电阻
6	ABD	I/O	Audio Amplifier选择，低电平时为D类功放，高电平时为AB类功放
7	ENA	I	Audio Amplifier使能端，内部下拉300KΩ电阻到地，高电平有效
8	ENB	I	Boost Converter使能端，内部下拉300KΩ电阻到地，高电平有效
9	IN-	I	反相输入端（差分-）
10	IN+	I	同相输入端（差分+）
11	BST	O	Boost Converter 升压值设置端
12	LIM	O	AGC使能和AGC Limiter 限幅值设置端
13	OUT-	O	反相输出端（BTL-）
14	PVDD	Power	Audio Amplifier电源（功率电源和模拟电源）输入端
15	PGND	GND	Audio Amplifier功率地
16	OUT+	O	同相输出端（BTL+）
17,18	V_{POUT}	Power	Boost Converter升压输出端
19,20	SW	I	Boost Converter功率整流端

注1　I: 输入端　　O: 输出端

■ 订购信息

H	T	8	6	2	xx

xx → 封装形式

产品型号	封装形式	顶面标记	工作温度范围	包装和供货形式
HT862MTE	TSSOP20L-PP	HT862MTE UVWXYZ *2	-40℃～85℃ （扩展工业级）	管装 46片/管

注2：WXYZ/UVWXYZ为内部生产跟踪随机编码。

■ 电气特性

● Absolute Maximum Ratings*3

PARAMETER	Symbol	MIN	MAX	UNIT
Supply voltage range	V_{BAT}	-0.3	V_{POUT}	V
Input voltage range	V_{IN}	-0.3	V_{POUT}+0.3	V
Operating temperature range	T_A	-40	85	℃
Operating junction temperature range	T_J	-40	170	℃
Storage temperature range	T_{STG}	-50	170	℃

*3: Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute–maximum–rated conditions for extended periods may affect device reliability.

● Recommended Operating Conditions

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
VBAT supply voltage range	V_{BAT}		2.8	3.6	V_{POUT} -0.5	V
High-level input voltage of ENA, ENB, SDA, SCL, ABD	V_{IH}		1.5			V
Low-level input voltage of ENA, ENB, SDA, SCL, ABD	V_{IL}				0.4	V
Operating temperature	T_a		-40	25	85	℃
Load impedance	R_L			4		Ω

● Electrical Characteristics*4

Condition: Ta=25ºC, V_{BAT} = 3.6V, f_{IN} = 1 kHz, Gain = 25dB, C_{IN} = 1uF, Limiter Off (if Limiter On, LIM terminal with 6M resistor grounded, 10h = 0x3C, THD+N≈5%), Battery tracking disabled (Point off), Load = 4ohm + 22uH, unless otherwise specified.

PARAMETER	Symbol	CONDITION		MIN	TYP	MAX	UNIT
VBAT supply voltage range	V_{BAT}	I²C read/write		3.0	3.6	V_{POUT} -0.5	V
		Boost + Amp work		2.8			
Boost on threshold voltage △	V_{B_TH}	Amplifier Output V_{RMS}			0.415× V_{BAT}		V
Start-up time △	t_{ON}	t_{BOOST_ON}, Boost only			1.5		ms
		t_{AMP_ON}, Audio Amplifier only			60		
Closed-loop voltage gain △	Av	GAIN = Floating		23.5	25	26.5	dB
		GAIN = L (30dB)		28	29.5	31	
Input impedance (per input pin)	R_{IN}	GAIN = Floating			31.4		KΩ
		GAIN = L			19.2		
Boost Converter							
Boost converter output voltage range △	V_{POUT}	R_{BOOST} = Floating		5.25	5.45	5.75	V
		R_{BOOST} = 33kΩ (±5%)		6.25	6.45	6.75	
		R_{BOOST} = 22kΩ (±5%)		7.25	7.45	7.75	
		R_{BOOST} = 12kΩ (±5%)		7.65	7.85	8.15	
Boost shut off time △	t_{BOOST_OFF}				208		ms
Boost converter input current limit △	I_L				3.5		A
Boost converter frequency	f_{BOOST}				800		kHz
Boost Converter + Class D							
Output power	Po	THD+N=1%	f=1kHz, V_{POUT} = 5.5V R_L=4Ω + 22uH		3.1		W
		THD+N≈5%			3.5		
		THD+N=10%			3.8		
		THD+N=1%	f=1kHz, V_{POUT} = 6.5V R_L=4Ω + 22uH		4.6		
		THD+N≈5%			5.0		
		THD+N=10%			5.5		
		THD+N=1%	f=1kHz, V_{POUT} = 7.5V R_L=4Ω + 22uH		5.8		
		THD+N≈5%			6.5		
		THD+N=10%			7.0		
		THD+N=1%	f=1kHz, V_{POUT} = 8.0V R_L=4Ω + 22uH		7.0		
		THD+N≈5%			8.0 (Instantaneous)		
		THD+N=10%			8.5 (Instantaneous)		
		THD+N=1%	f=1kHz, V_{POUT} = 5.5V R_L=8Ω + 33uH		1.7		
		THD+N≈5%			1.85		
		THD+N=10%			2.1		
		THD+N=1%	f=1kHz, V_{POUT} = 6.5V R_L=8Ω + 33uH		2.4		
		THD+N≈5%			2.6		
		THD+N=10%			2.9		
		THD+N=1%	f=1kHz, V_{POUT} = 7.5V R_L=8Ω + 33uH		3.1		
		THD+N≈5%			3.5		
		THD+N=10%			3.8		
		THD+N=1%	f=1kHz, V_{POUT} = 8.0V R_L=8Ω + 33uH		3.7		
		THD+N≈5%			4.0		
		THD+N=10%			4.5		
Total harmonic distortion plus noise	THD+N	Po=0.5W	R_L=4Ω+22uH, f=1kHz		0.02		%
		Po=1.0W			0.04		

Noise output voltage	V_N	Differential input floating, f=20Hz~20kHz, A-weighted, Av=25dB			45		μV_{rms}
Efficiency (Class D + Boost)	η	V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 0.6W			85		%
		V_{POUT} = 5.5V	V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 3.0W		80		
		V_{POUT} = 6.5V			75		
		V_{POUT} = 7.5V			74		
		V_{POUT} = 8.0V			71		
		V_{BAT} = 4.2V, R_L = 8Ω+22uH, Po = 0.3W			85		
		V_{POUT} = 5.5V	V_{BAT} = 4.2V, R_L =8Ω+33uH, Po = 2.0W		85		
		V_{POUT} = 6.5V			80		
		V_{POUT} = 7.5V			77		
		V_{POUT} = 8.0V			74		
Operating quiescent current	I_{BAT}	Input Grounded, With or without load			4		mA
Quiescent current in mute mode	I_{MUTE}	Input Grounded, With or without load			1.5		mA
Shutdown quiescent current	I_{SD}	Input Grounded, With or without load			1		μA
Class D switching frequency	$f_{ClasS-D}$				400		kHz
Boost Converter + Class AB							
Output power	Po	THD+N=1%	f=1kHz, V_{POUT} = 5.5V R_L=4Ω + 22uH		2.9		W
		THD+N≈5%			3.4		
		THD+N=10%			3.65		
		THD+N=1%	f=1kHz, V_{POUT} = 6.5V R_L=4Ω + 22uH		4		
		THD+N≈5%			4.75		
		THD+N=10%			5.1		
		THD+N=1%	f=1kHz, V_{POUT} = 7.5V R_L=4Ω + 22uH		5.4 (Instantaneous)		
		THD+N≈5%			6.0 (Instantaneous)		
		THD+N=10%			6.25 (Instantaneous)		
		THD+N=1%	f=1kHz, V_{POUT} = 8.0V R_L=4Ω + 22uH		5.4 (Instantaneous)		
		THD+N≈5%			6.0 (Instantaneous)		
		THD+N=10%			6.25 (Instantaneous)		
		THD+N=1%	f=1kHz, V_{POUT} = 5.5V R_L=8Ω + 33uH		1.65		
		THD+N≈5%			1.85		
		THD+N=10%			2.1		
		THD+N=1%	f=1kHz, V_{POUT} = 6.5V R_L=8Ω + 33uH		2.35		
		THD+N≈5%			2.7		
		THD+N=10%			2.95		
		THD+N=1%	f=1kHz, V_{POUT} = 7.5V R_L=8Ω + 33uH		3.1		
		THD+N≈5%			3.5		
		THD+N=10%			3.9		
		THD+N=1%	f=1kHz, V_{POUT} = 8.0V R_L=8Ω + 33uH		3.7		
		THD+N≈5%			4.35		
		THD+N=10%			4.6		
Total harmonic distortion plus noise	THD+N	P_O=0.5W	R_L=4Ω, f=1kHz		0.04		%
		P_O=1.0W			0.05		
Noise output voltage	V_N	Differential input floating, f=20Hz~20kHz, A-weighted, Av=25dB			45		μV_{rms}

Efficiency (Class AB + Boost)	η	V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 0.5W		40		%
		V_{POUT} = 5.5V; V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 3.0W		65		%
		V_{POUT} = 6.5V; V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 3.0W		50		%
		V_{POUT} = 7.5V; V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 3.0W		40		%
		V_{POUT} = 8.0V; V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 3.0W		35		%
		V_{BAT} = 4.2V, R_L = 8Ω+22uH, Po = 0.3W		40		%
		V_{POUT} = 5.5V; V_{BAT} = 4.2V, R_L = 8Ω+22uH, Po = 2.0W		75		%
		V_{POUT} = 6.5V; V_{BAT} = 4.2V, R_L = 8Ω+22uH, Po = 2.0W		60		%
		V_{POUT} = 7.5V; V_{BAT} = 4.2V, R_L = 8Ω+22uH, Po = 2.0W		50		%
		V_{POUT} = 8.0V; V_{BAT} = 4.2V, R_L = 8Ω+22uH, Po = 2.0W		46		%
Operating quiescent current	I_{BAT}	Input Grounded, With or without load		30		mA
Quiescent current in mute mode	I_{MUTE}	Input Grounded, With or without load		0.6		mA
Shutdown quiescent current	I_{SD}	Input Grounded, With or without load		1		μA
Automatic Gain Control (AGC)						
AGC gain range	Av_{AGC}			30		dB
AGC gain step Δ	STP_{AGC}		40	80		/
AGC attack time Δ	t_{A_AGC}			12		ms/dB
AGC release time Δ	t_{R_AGC}			150		ms/dB
Limiter level (Peak)Δ	V_{LIM_L}	LIM Floating, 10h = 0x3C		0.95×V_{POUT}		V
VBAT vs. Limiter slope Δ	S_{BAT}	V_{POUT} = 5.5V		2.6		V/V
		V_{POUT} = 6.5V		3.1		V/V
		V_{POUT} = 7.5V		3.5		V/V
		V_{POUT} = 8.0V		4.1		V/V
AGC battery tracking point Δ	Point1	R_{AGC} = 33kΩ (±5%)		3.3		V
	Point2	R_{AGC} = 22kΩ (±5%)		3.5		V
	Point3	R_{AGC} = 12kΩ (±5%)		3.8		V
Thermal Foldback (TFB)						
Over temperauture protection point Δ	OTP			170		℃
Over temperature protection hysteresis	OTP_{hys}			30		℃
Over temperature protection recovery point	OTPR			140		
Thermal foldback trig point Δ	TFB			150		℃
TFB attack time Δ	t_{A_TFB}			1200		ms/dB
TFB release time Δ	t_{R_TFB}			2400		ms/dB
Input/Output						
Gain control pin voltage	V_{GAIN}	Gain = 30dB	0		0.25× V_{BAT}	V
		Gain = 25dB	0.45× V_{BAT}		0.55× V_{BAT}	V
		MUTE	0.75× V_{BAT}		V_{BAT}	V
Battery tracking control pin (AGC) voltage	V_{AGC}	AGC without battery tracking (Floating)	2			V
		Point 1(3.3V), R_{AGC} = 33kΩ (±5%)	1.2		1.5	V
		Point 2(3.5V), R_{AGC} = 22kΩ (±5%)	0.85		1.1	V
		Point 3(3.8V), R_{AGC} = 12kΩ (±5%)	0		0.6	V

Boost voltage control pin (BST) voltage	V_{BST}	V_{POUT} = 5.5V (Floating)	2			V
		V_{POUT} = 6.5V, R_{BST} = 33kΩ (±5%)	1.2		1.5	
		V_{POUT} = 7.5V, R_{BST} = 22kΩ (±5%)	0.85		1.1	
		V_{POUT} = 8.0V, R_{BST} = 12kΩ (±5%)	0		0.6	
AGC control pin output current	I_{AGC}			40		μA
BOOST control pin output current	I_{BOOST}			40		μA
Internal pulldown resistor of ENA, ENB, ABD	R_{DOWN}			300		kΩ
High-level input voltage of ENA, ENB, ABD, SDA, SCL	V_{IH}		1.5			V
Low level input voltage of ENA, ENB, ABD, SDA, SCL	V_{IL}				0.4	V

*4: Depending on parts and PCB layout, characteristics may be changed.
Δ: Parameters configurable in software control mode

● I²C Timing Characteristics

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
Frequency, SCL	f_{SCL}				400	kHz
Pulse duration, SCL high	$t_{W(H)}$		0.6			μs
Pulse duration, SCL low	$t_{W(L)}$		1.3			μs
Setup time, SDA to SCL	t_{SU1}		100			ns
Hold time, SCL to SDA	t_{h1}		10			ns
Bus free time between stop and start condition	$t_{(buf)}$		1.3			μs
Setup time, SCL t start condition	t_{SU2}		0.6			μs
Hold time, start condition to SCL	t_{h2}		0.6			μs
Setup time, SCL to stop condition	t_{SU3}		0.6			μs

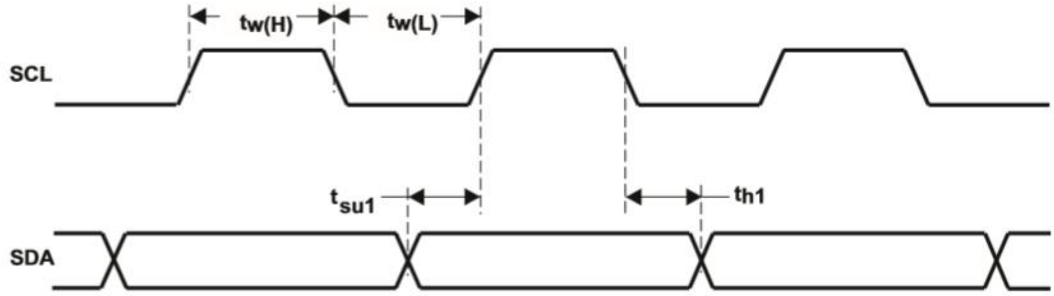


Fig. 1 I²C SCL and SDA Timing

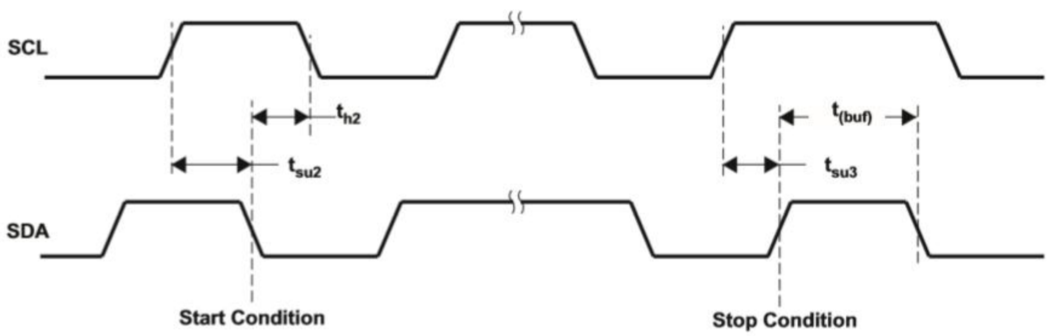


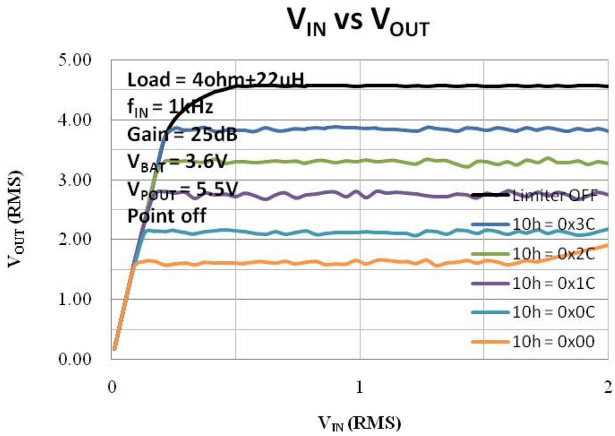
Fig. 2 I²C Start and Stop Conditions Timing

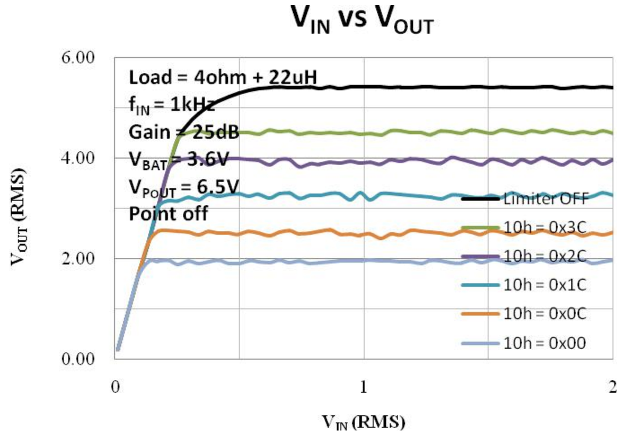
■ 典型特性曲线

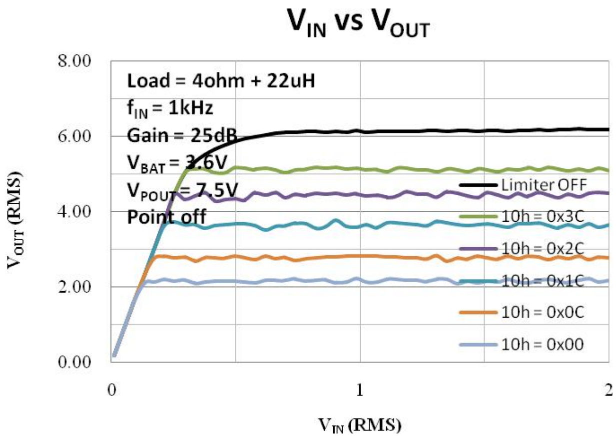
Condition: V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, unless otherwise specified.

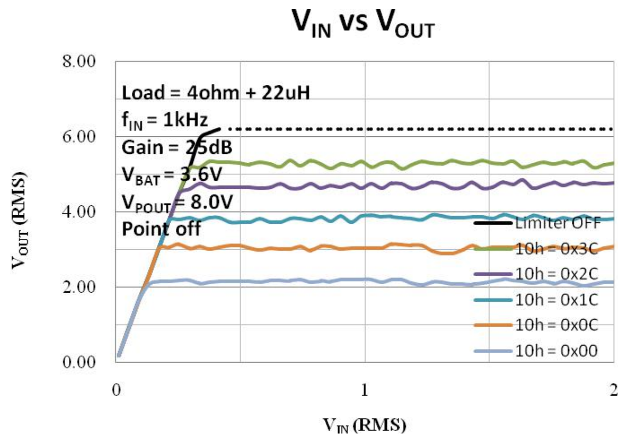
AGC

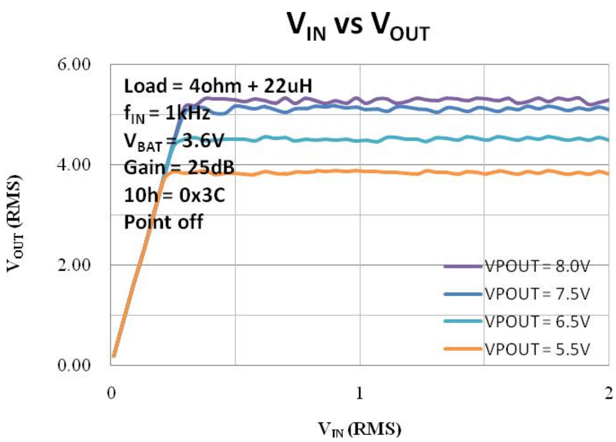
Characteristics below are measured in Class D mode, but Class AB mode is also available.
Condition: V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, Limiter ON (LIM terminal with 6M resistor grounded, 10h = 0x3C), Battery tracking enabled (Point 3), Output = Load + Filter, Load = 4ohm + 22uH, Filter = 100ohm + 47nF, unless otherwise specified.



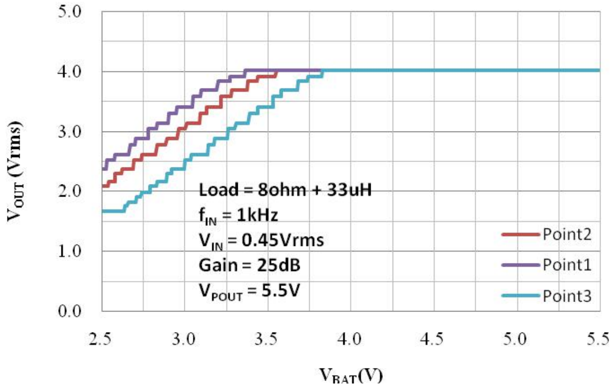




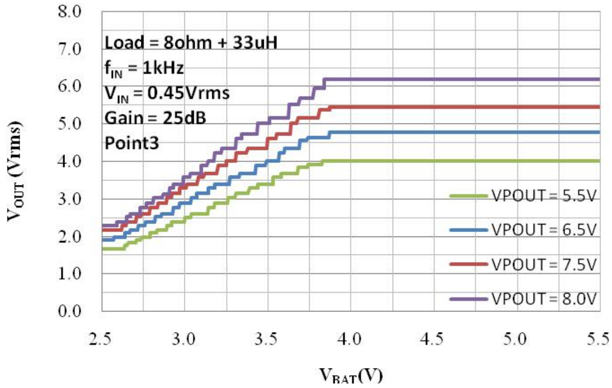




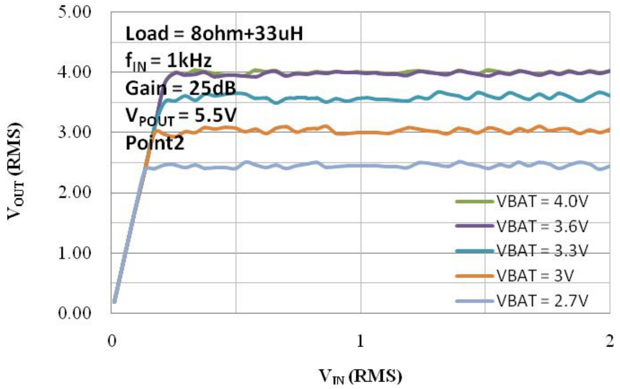
V_{BAT} vs V_{OUT}



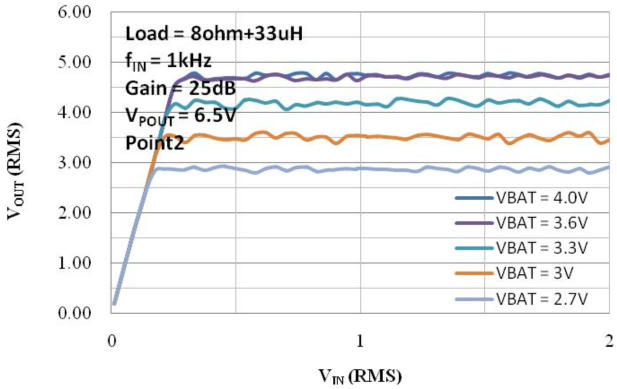
V_{BAT} vs V_{OUT}



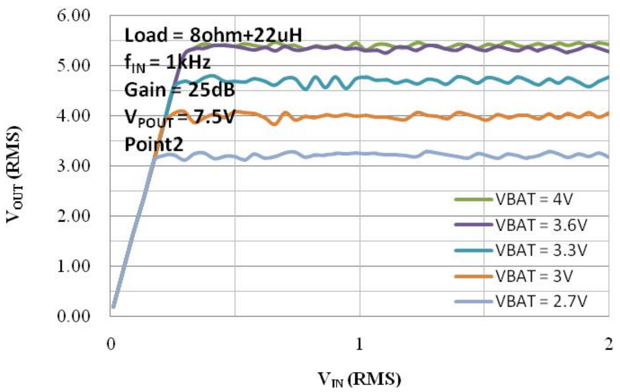
V_{IN} vs V_{OUT}



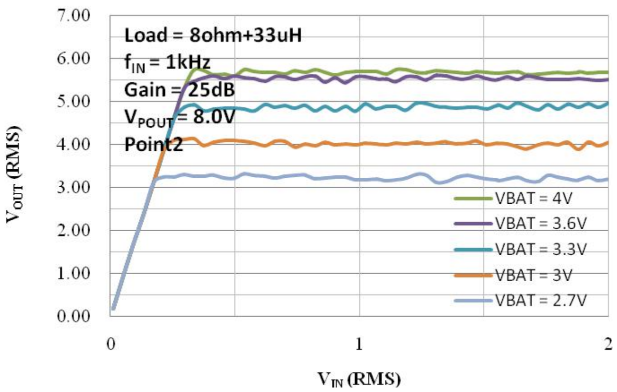
V_{IN} vs V_{OUT}



V_{IN} vs V_{OUT}



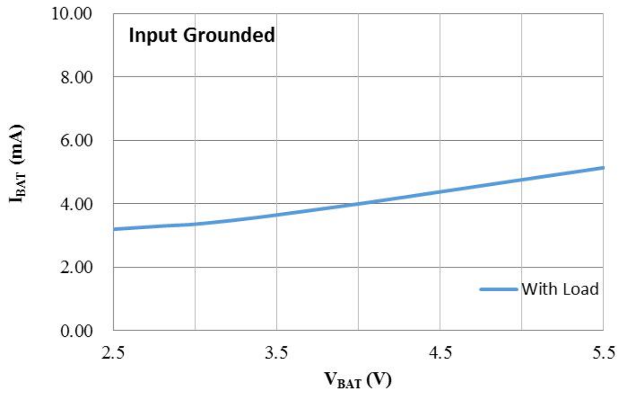
V_{IN} vs V_{OUT}



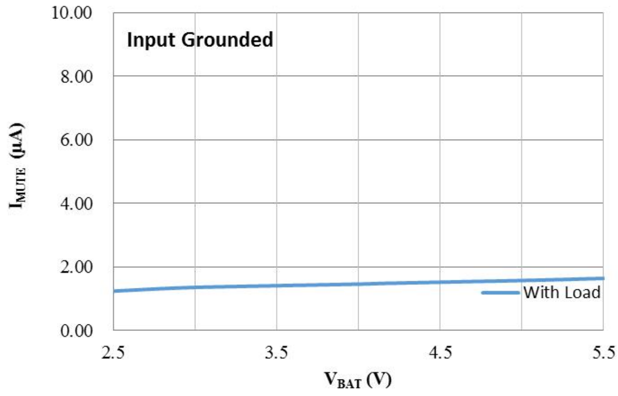
BOOST + Class D

Condition: V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, Limiter Off (if Limiter On, LIM terminal with 6M resistor grounded, 10h = 0x3C), Battery tracking disabled (Point off), Output = Load + Filter, Load = 4ohm + 22uH, Filter = 100ohm + 47nF, unless otherwise specified.

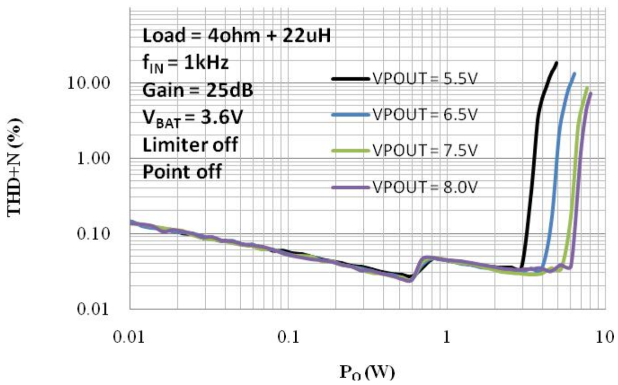
V_{BAT} vs I_{BAT}



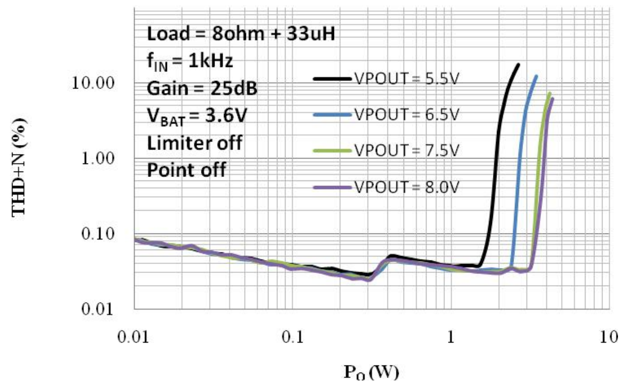
V_{BAT} vs I_{MUTE}



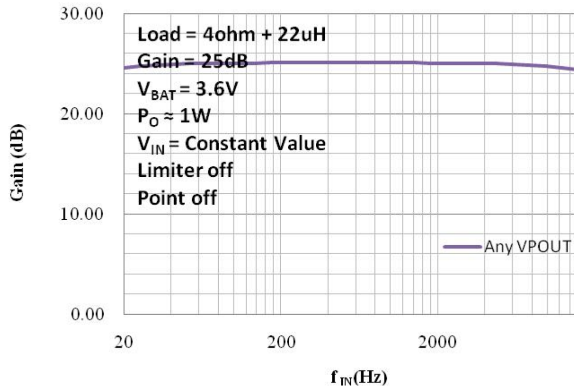
P_O vs THD+N



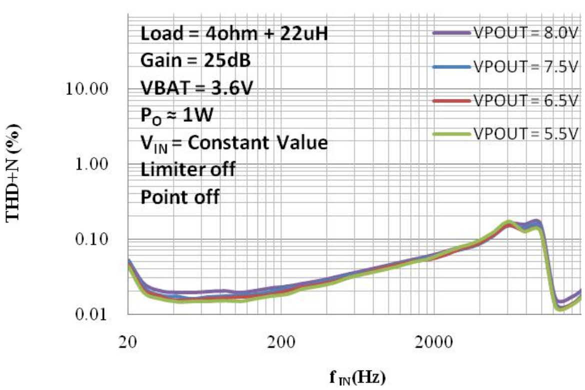
P_O vs THD+N



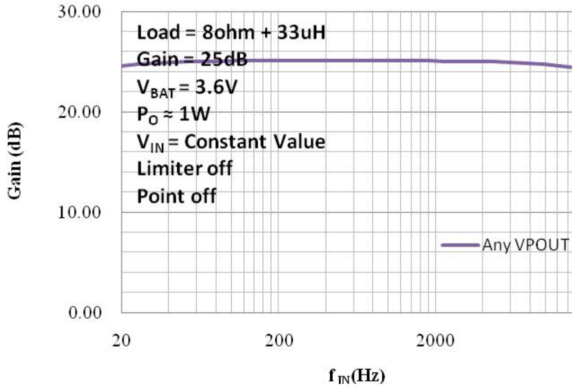
f_{IN} vs Gain



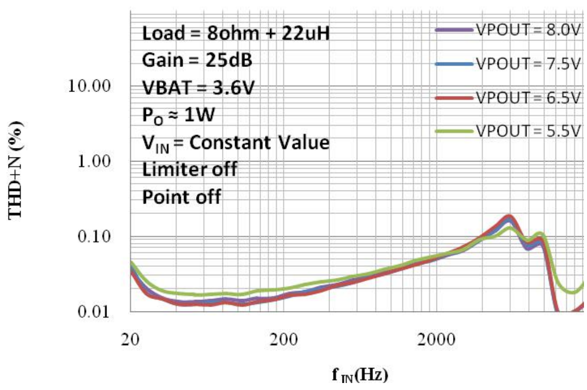
f_{IN} vs THD+N



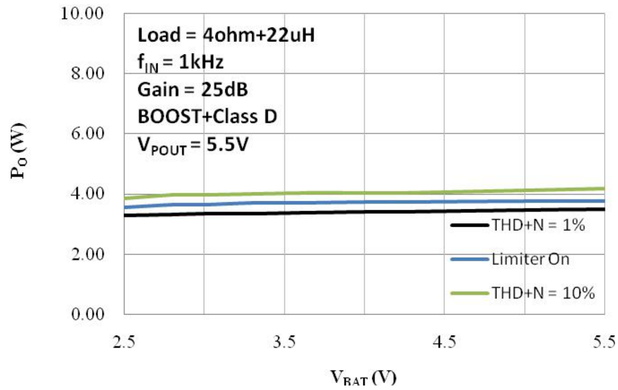
f_{IN} vs Gain



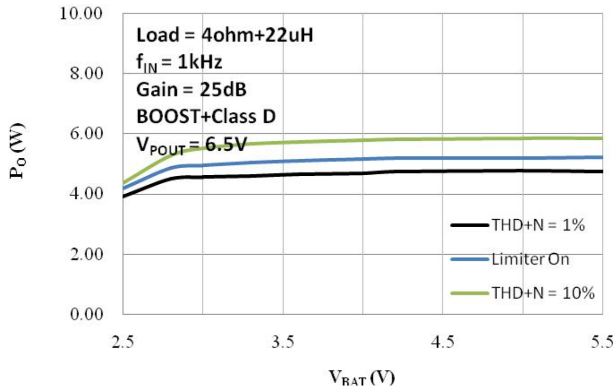
f_{IN} vs THD+N



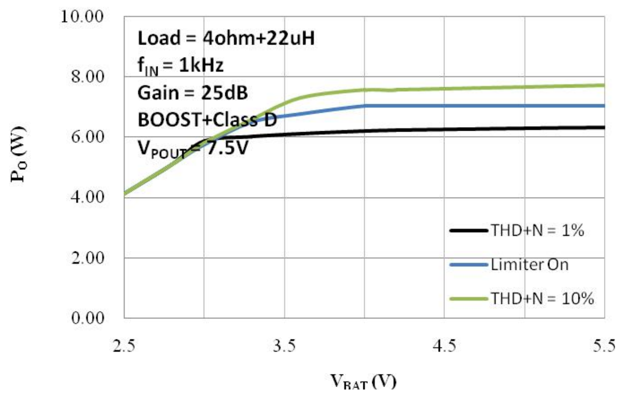
V_{BAT} vs P_O



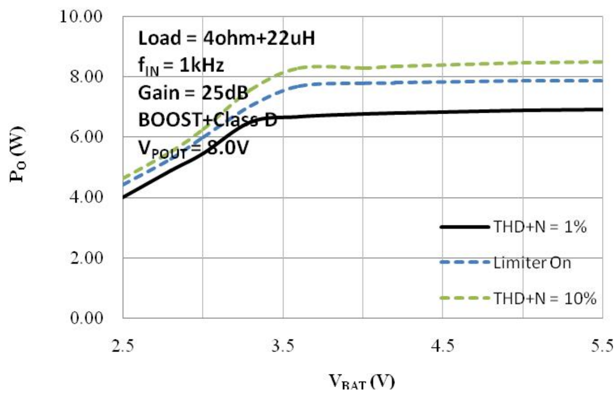
V_{BAT} vs P_O



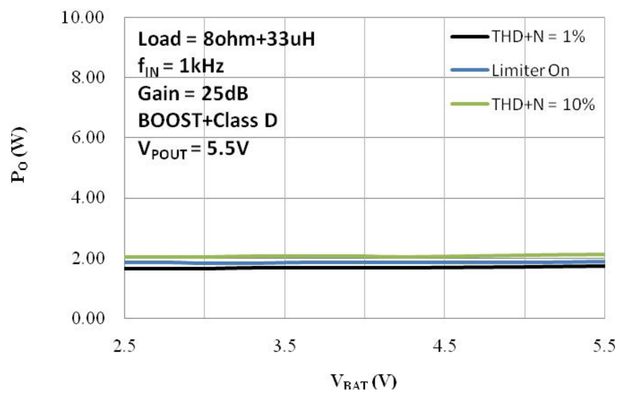
V_{BAT} vs P_O



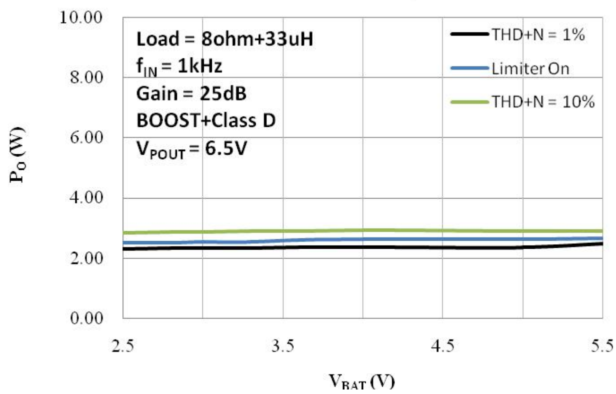
V_{BAT} vs P_O



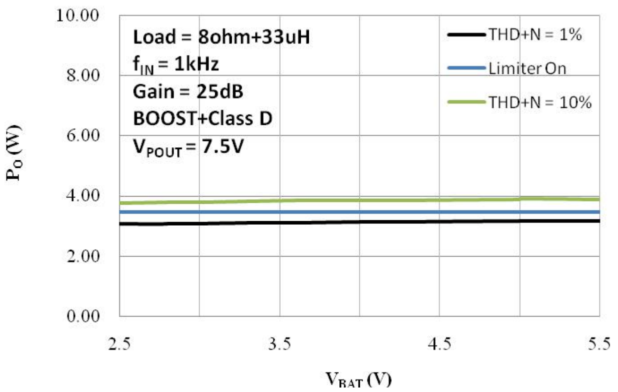
V_{BAT} vs P_O



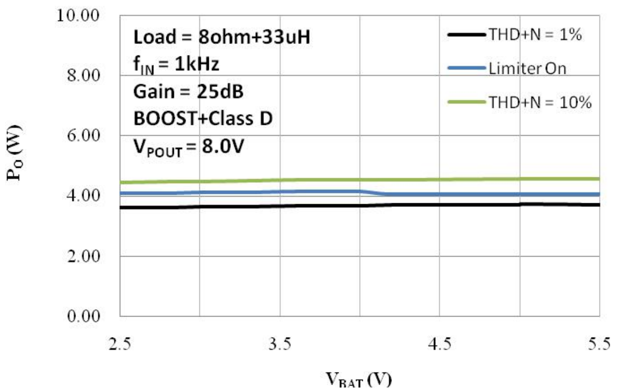
V_{BAT} vs P_O



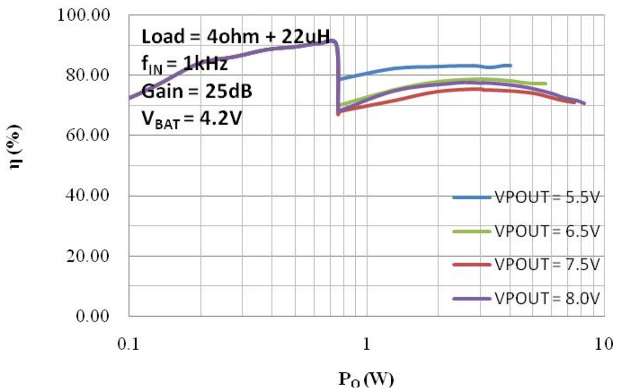
V_{BAT} vs P_O



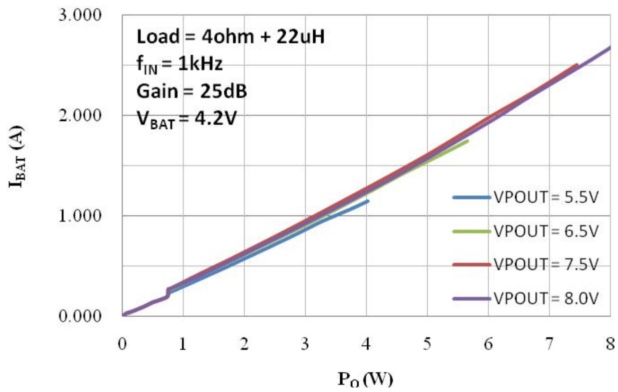
V_{BAT} vs P_O



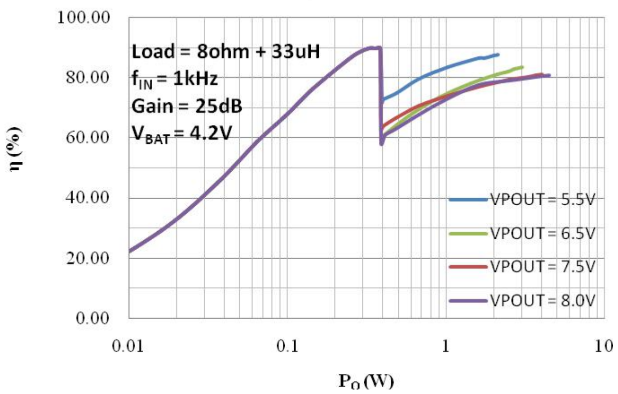
P_O vs η



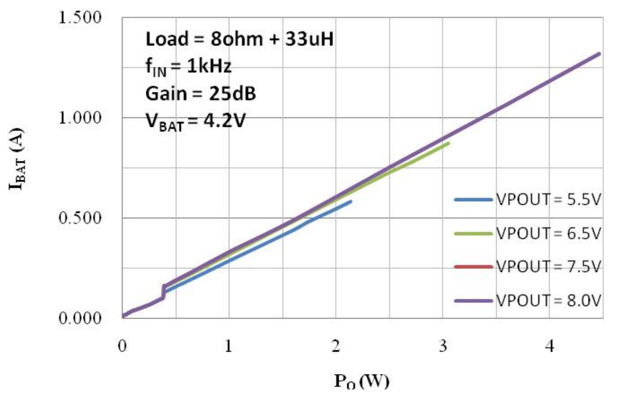
P_O vs I_{BAT}



P_O vs η

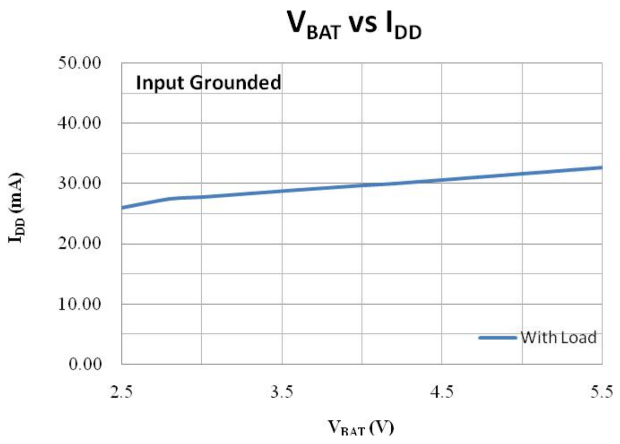


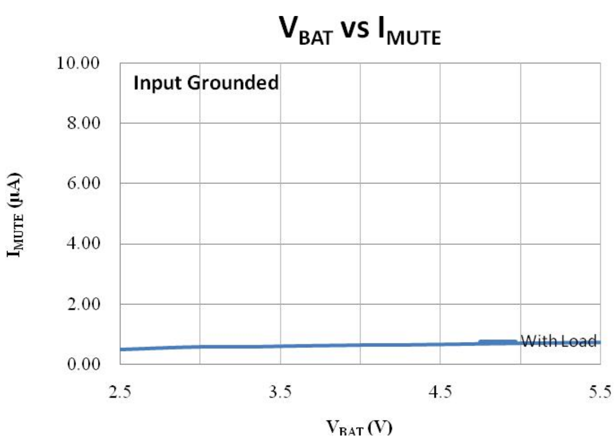
P_O vs I_{BAT}

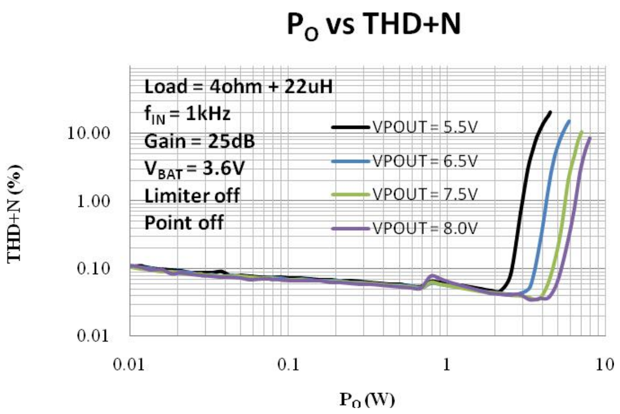


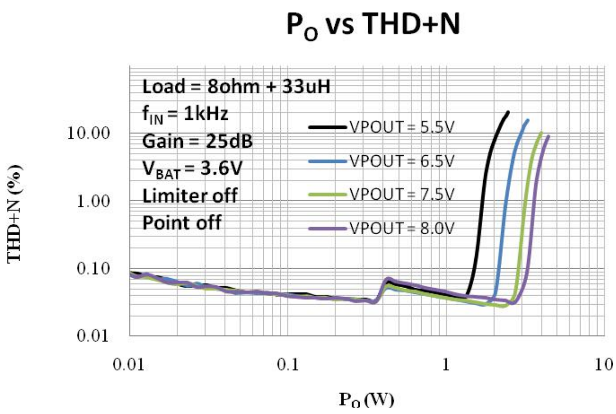
BOOST + Class AB

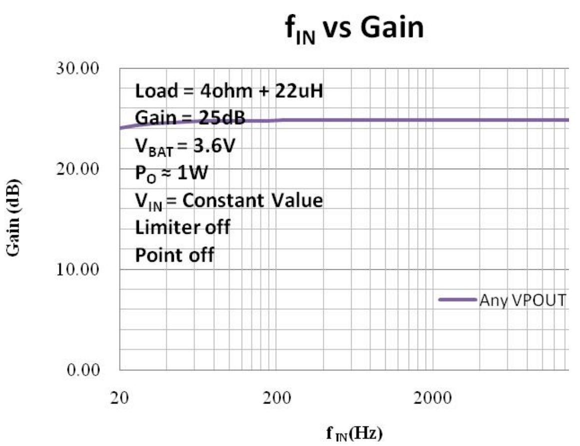
Condition: V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, Limiter Off (if Limiter On, LIM terminal with 6M resistor grounded, 10h = 0x3C), Battery tracking disabled (Point off), Output = Load = 4ohm + 22uH, unless otherwise specified.

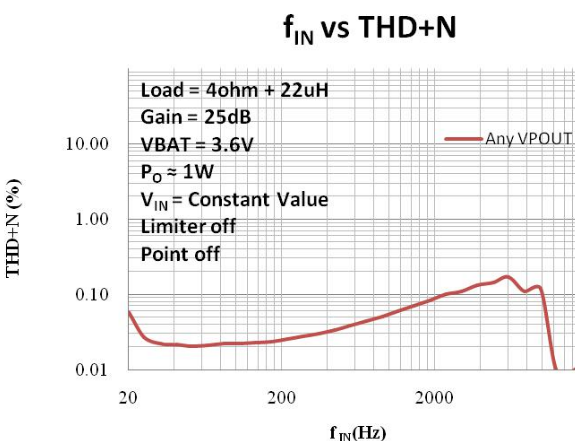




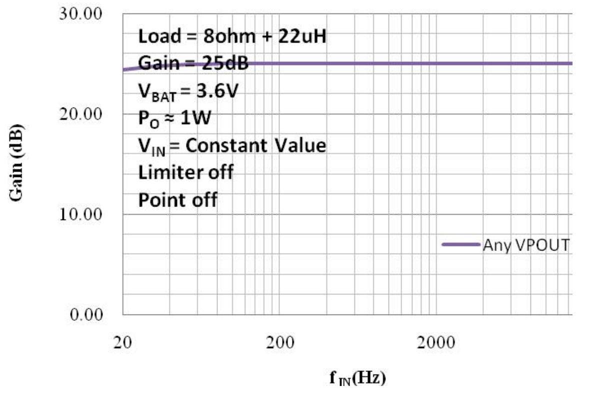




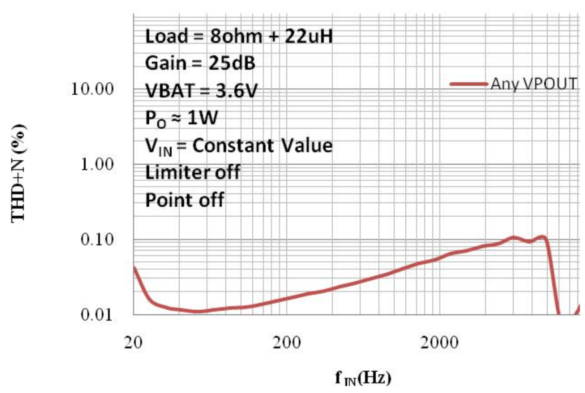




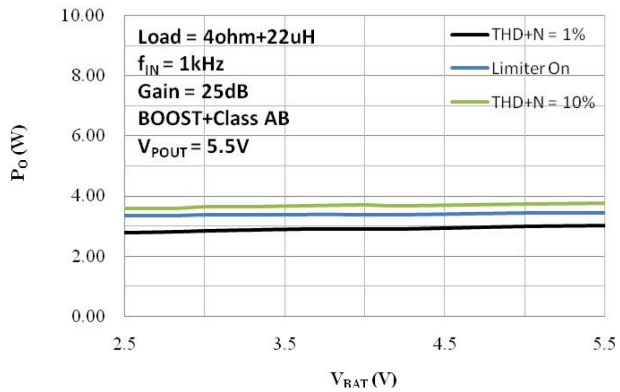
f_{IN} vs Gain



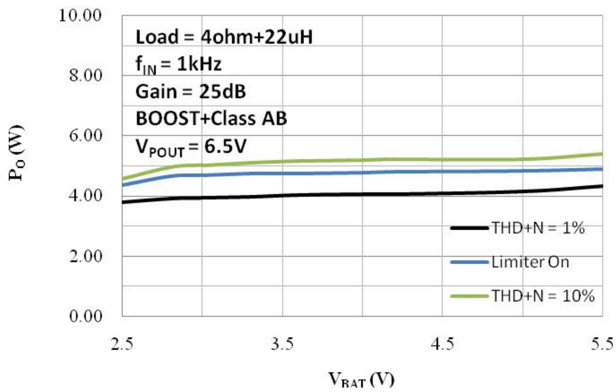
f_{IN} vs THD+N



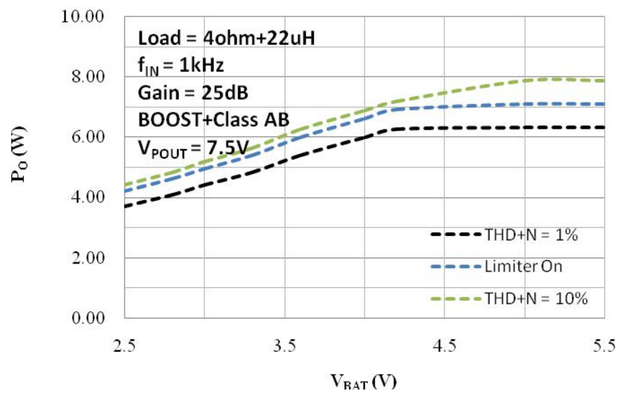
V_{BAT} vs P_O



V_{BAT} vs P_O



V_{BAT} vs P_O



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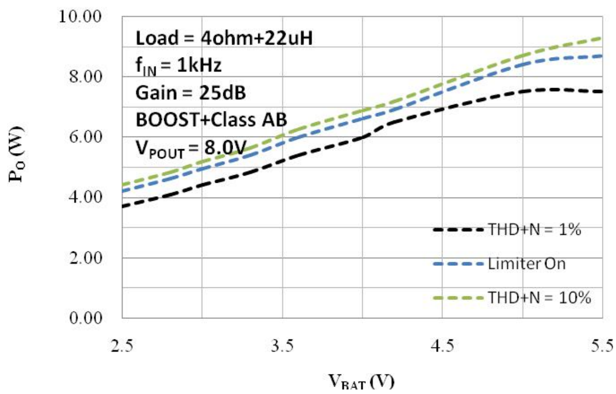
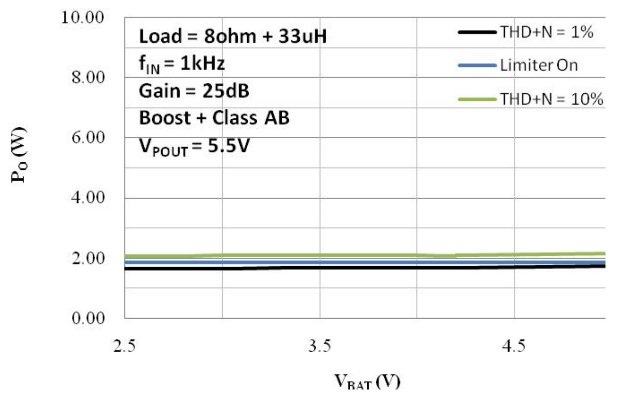
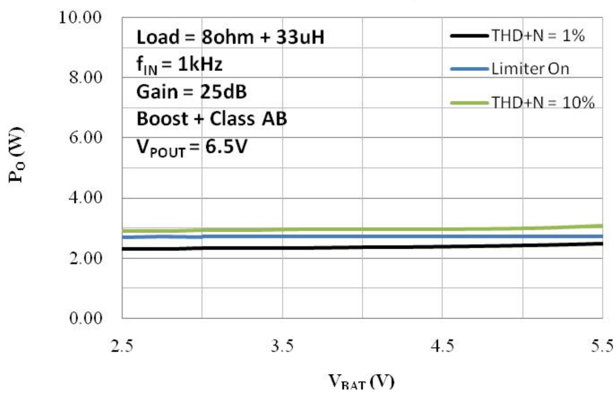


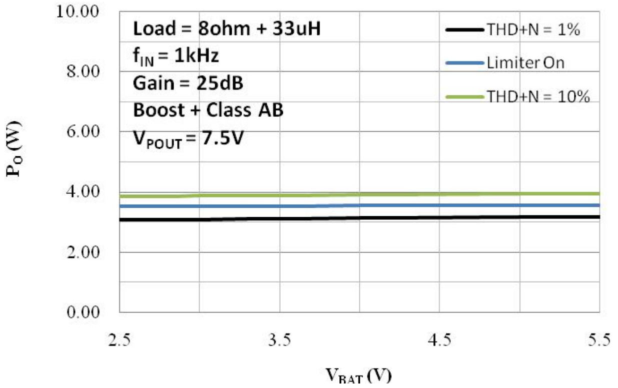
V_{BAT} vs P_O



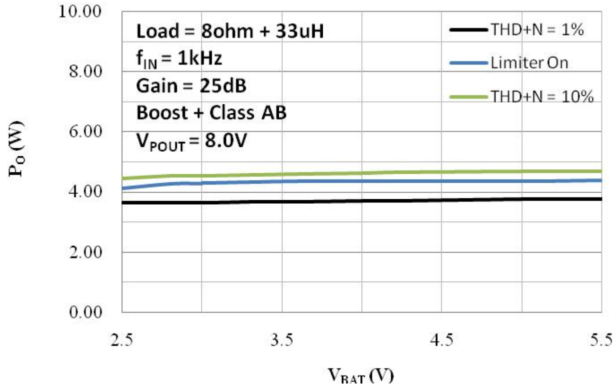
V_{BAT} vs P_O



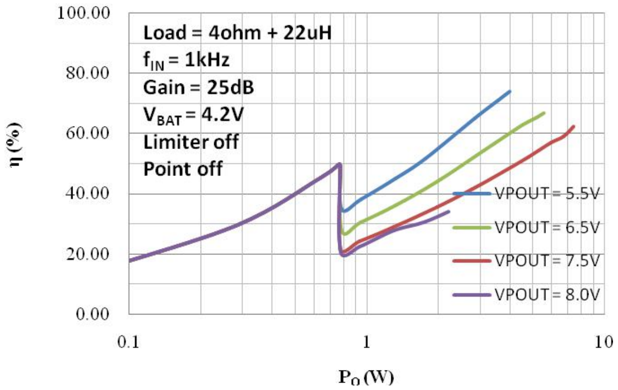
V_{BAT} vs P_O



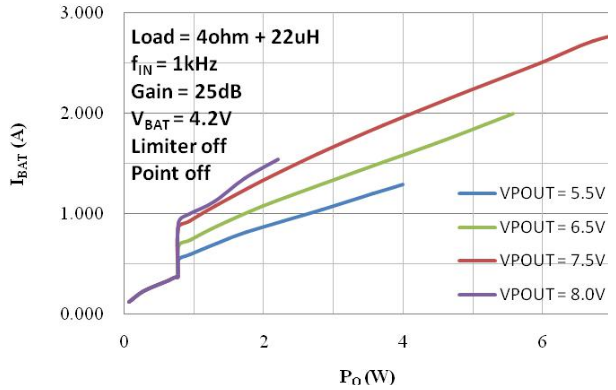
V_{BAT} vs P_O



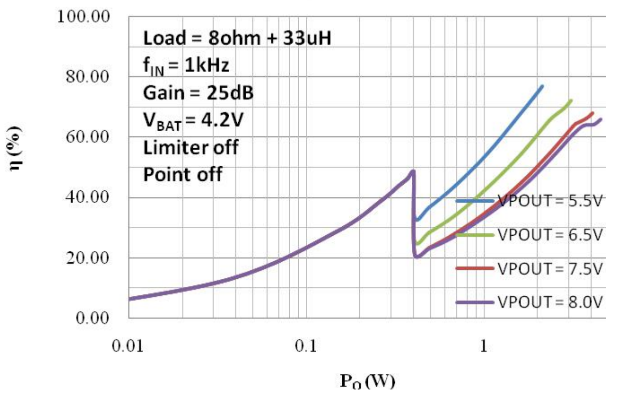
P_O vs η



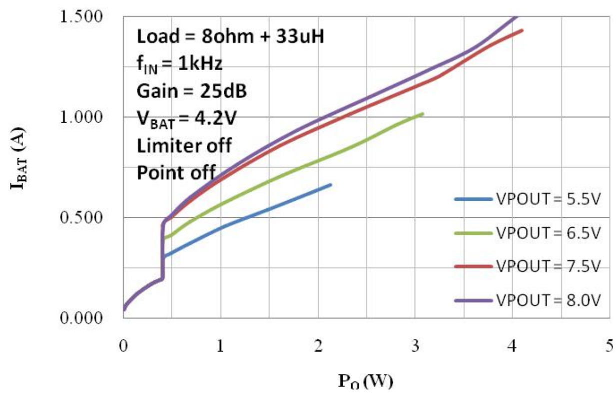
P_O vs I_{BAT}



P_O vs η



P_O vs I_{BAT}



■ 功能描述及应用信息

1. 参数定义

自动增益控制(Automatic gain control, AGC for short) ：该功能主要包括限幅（Limiter）功能和电池跟踪（Battery tracking）功能。

限幅（Limiter）：该功能开启后，当功放输出电压大于限幅值，功放增益将自动降低，使功放输出在维持限幅值。

限幅值（Limiter level, V_{LIM_L} for short）：AGC允许的最大输出幅度值，超过该值，AGC电路就会降低系统增益。可通过硬件或软件控制模式设置修改该值。

电池跟踪（Battery tracking, point for short）：该功能开启后，当输入电池电压低于电池跟踪拐点，限幅值将自动降低。虽然这将一定程度的降低系统功率，但减小了电池电流，降低了电池低电量时被拉死的风险，增加了电池的续航时间。

电池跟踪拐点（Battery tracking point, point for short）：电池跟踪功能开启后，当输入电池电压低于电池跟踪拐点，限幅值将自动降低。虽然这将一定程度的降低系统功率，但减小了电池电流，降低了电池低电量时被拉死的风险，增加了电池的续航时间。可通过硬件或软件控制模式设置修改该值。

电池跟踪斜率（V_{BAT} vs Limiter slope, slope for short）：电池跟踪功能开启后，当输入电池电压低于电池跟踪拐点，功放输出电压将随着电池电压的降低以该斜率降低。可通过软件控制模式设置修改该值。

过温限幅（Thermal foldback, TFB for short）：该功能开启后，当芯片因环境温度过高、功放过载、系统散热性能不佳等原因引起结温高于过温限幅点（TFB）时，功放将自动减小增益，以减小芯片功率耗散从而降低结温；随着温度的降低，当结温小于过温限幅点（TFB）时，功放又将自动增加增益，直到结温到达过温限幅点（TFB）。如此循环。

过温限幅点（Thermal foldback trig point, TFB for short）：过温限幅功能开启后，当芯片结温上升达到该值，功放增益自动减小。可通过软件控制模式设置修改该值。

启动时间（Attack time, t_A for short）：AGC增益减小的速率，默认值为12ms /dB；TFB增益减小的速率，默认值为1200ms/dB。均

可通过软件控制模式设置修改该值。

释放时间（Release time, t_R for short）：AGC增益增加的速率，默认值为150ms/dB；TFB增益增加的速率，默认值为2400ms/dB。均可通过软件控制模式设置修改该值。

自适应升压（Adaptive boost）：只有当输入信号大于升压阈值时，HT862才会进入升压模式，该功能可增加系统整体效率，在播放音乐时大大提高锂电池续航时间。

升压阈值（Boost on threshold voltage, V_{B_TH} for short）：音频输入信号逐渐增大并大于该值后，HT862启动升压。可通过软件控制模式设置修改该值。

2. 功能描述

2.1. 自动增益控制（AGC）

自动增益控制(Automatic gain control, AGC for short)功能主要包括限幅（Limiter）功能和电池跟踪（Battery tracking）功能，它能提供自动增益调节以调节声音大小，使音乐更悦耳，防止喇叭损坏，增加电池续航时间，降低电池低电量时被拉死的风险。

2.1.1 限幅（Limiter）功能

该功能开启后，当功放输出电压大于限幅值，功放增益将以默认值t_A = 12ms/dB的速率自动降低，使功放输出维持在限幅值。随后，如果过功放输出电压小于限幅值，功放增益将以默认值t_R = 150ms/dB的速率自动增加。增加或减小的每步增益0.75dB或0.375dB(默认值)，可通过软件控制模式修改，位于寄存器0x0A。该过程示意图如下。

限幅值、启动时间/释放时间都能通过软件控制模式设置修改（分别位于0x10, 0x0B, 0x0C寄存器）。通过这些参数的修改，HT862能将输出限制在各种功率和失真条件下，以更悦耳的声音呈现音乐。

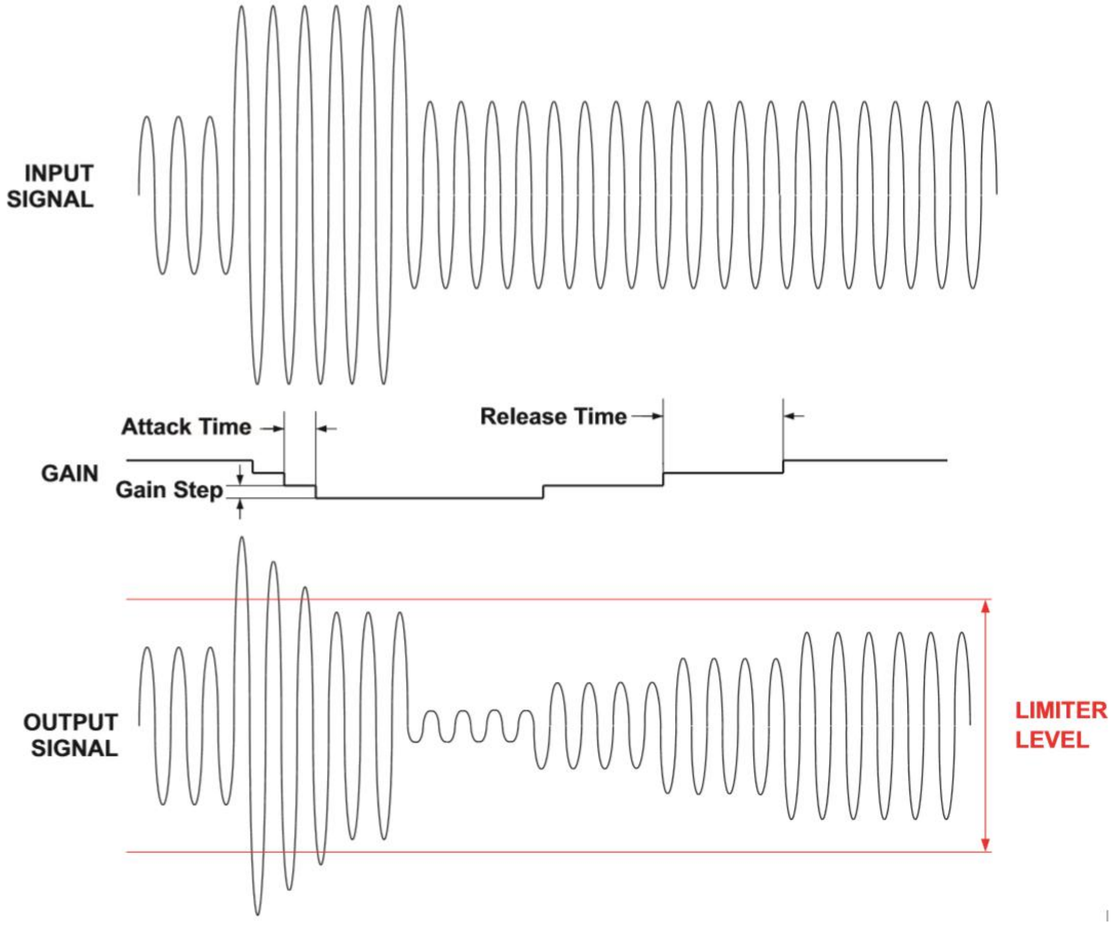


Fig. 3 AGC Limiter Function

其中，限幅值还能通过硬件控制模式控制。在硬件控制模式下，设置LIM引脚，即能控制AGC的开关并设置AGC限幅值。LIM引脚内部电路如下图所示，其中R1 ≈ 615kohm, R2 ≈ 227kohm, R3 ≈ 380kohm。LIM引脚直接接地，AGC功能关闭。LIM引脚悬空或通过外围加上拉电阻R_H或下拉电阻R_L到V_{POUT}实现不同的AGC限幅值(Limiter Level)。Limiter Level $V_{LM\_L\,(Peak)} \approx (0.5V_{POUT} - V_{LIM\_COM}) \times 5$。典型参数如下表所示。

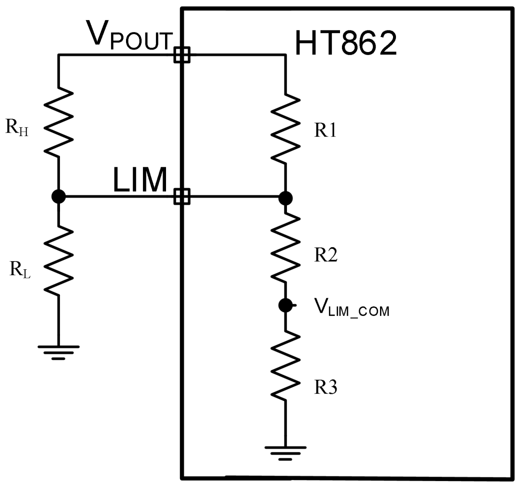


Fig. 4 LIM Terminal Configuration

Table. 1 Typical AGC Limiter Level Configuration in Hardware Mode

$R_L(\Omega)$	$R_H(\Omega)$	Limiter level (Peak)	THD+N(Class D)	THD+N(Class AB)
NC	NC	$\approx 0.95\times V_{POUT}$	≈3%	≈5%
NC	6M	$\approx 0.87\times V_{POUT}$	≈1%	≈3%
6M	NC	$\approx 1.0\times V_{POUT}$	≈5%	≈7%
Short	NC	AGC Disabled		

2.1.2 电池跟踪（Battery Tracking）功能

该功能开启后，能实时跟踪电池电压和音频信号幅度，当电池电压低于电池跟踪拐点（point）且音频信号幅度过大时，功放将自动降低增益，即限幅值将自动减小，以提高电池续航时间，降低电池低电量时被拉死的风险。

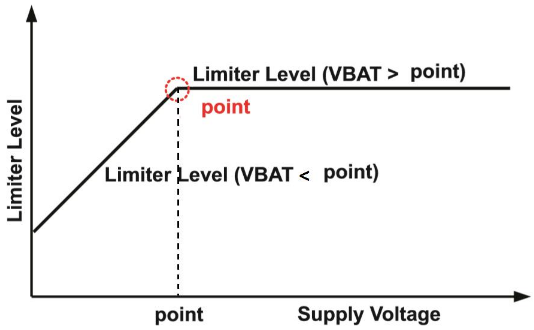


Fig. 5 Limiter Level vs Supply Voltage

电池跟踪拐点可通过硬件或软件控制模式设置修改，软件控制模式时位于寄存器0x09。硬件控制模式下，只需在AGC引脚接不同电阻到地，即可实现不同的电池跟踪拐点。AGC悬空时，电池跟踪功能关闭。如下表所示。

Table. 2 AGC Battery Tracking Configuration in Hardware Mode

Function	Resistor on AGC pin to GND	Battery tracking point
Battery tracking disabled	Floating	Disabled
Battery tracking point1	33kΩ	3.3V
Battery tracking point2	22kΩ	3.5V
Battery tracking point3	12kΩ	3.8V

电池跟踪斜率则只能通过软件控制模式修改，其位于寄存器0x14, 0x15, 0x16。

下图4是电池跟踪功能的运行过程举例，说明如下：

Phase 1：电池正常放电，电池电压逐渐降低但始终大于电池跟踪拐点，限幅值始终不变，功放增益由输出是否达到限幅值决定；

Phase 2：电池继续放电，电池电压继续降低并小于电池跟踪拐点，限幅值随着电池电压的降低以电池跟踪斜率自动减小，功放增益、输出功率、电池电流随之减小；

Phase 3：电池电压不变，限幅值、功放增益、输出功率、电池电流保持不变；

Phase 4：电池充电，电池电压逐渐升高，限幅值、功放增益、输出功率、电池电流逐渐增大，直到电池电压大于电池跟踪拐点；

Phase 5：电池电压不变且高于电池跟踪拐点，如此时功放输出电压仍小于限幅值，功放增益将继续以释放时间的速率增加；

Phase 6: 电池电压不变仍高于电池跟踪拐点，功放增益增加至设定增益或功放输出达到限幅值，随后保持不变。

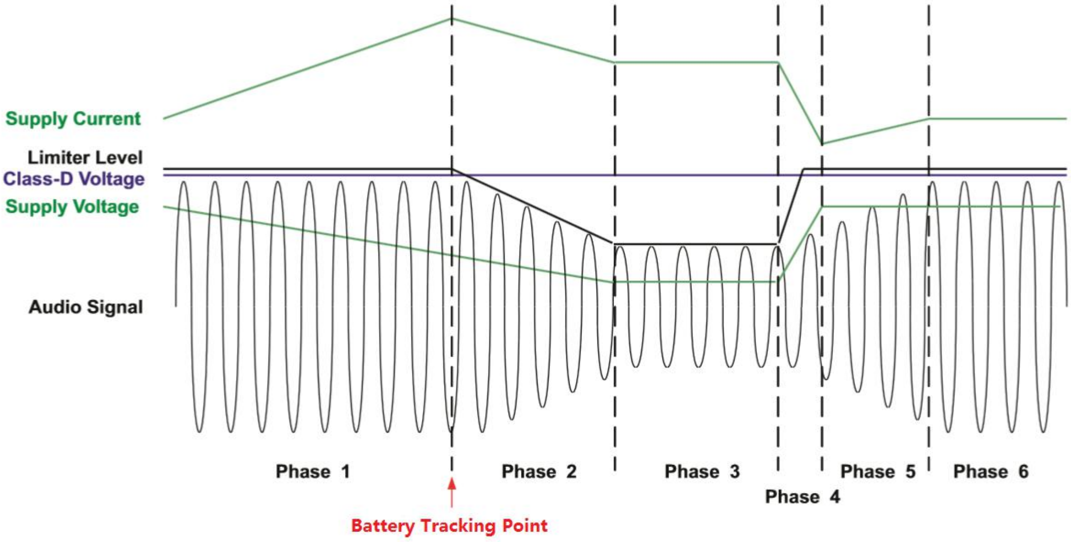


Fig. 6 Battery Tracking Function Operation Example

2.2. 自适应同步升压（Adaptive Synchronous Boost Converter）

HT862内置了同步升压模块，将输入电池电压V_{BAT}升压至V_{POUT}并供给功放工作，以提高锂电供电应用的输出功率，并节省了外置的二极管。V_{POUT}具有5.5V, 6.5V, 7.5V, 8.0V四种选择，可通过硬件和软件控制模式控制。软件控制模式通过寄存器0x09设置修改，硬件控制模式通过在BST引脚外接电阻到地实现，如下表所示。

Table. 3 BOOST Terminal Configuration in Hardware Mode

Resistor on BST pin to GND	V_{POUT}
Floating	5.5V
33kΩ	6.5V
22kΩ	7.5V
12kΩ	8.0V

在8.0V工作模式下，建议在SW和V_{POUT}之间加入肖特基二极管（建议参数V_{RRM} > 12V, V_{FM}＜0.5V, I_F≥3 A，推荐使用SS54），并工作在Limiter On条件下，以增加系统可靠性。

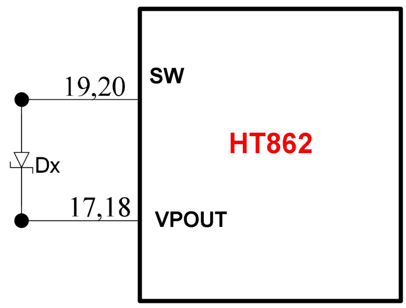


Fig. 7 Schottky diode for 8.0V boost converter

HT862集成的同步升压模块还具有自适应功能，即只有当输出信号大于升压阈值时，HT862才会进入升压模式，该功能能增加系统整体效率，在播放音乐时大大提高锂电池续航时间。升压阈值只能通过软件控制模式设置修改（位于0x19寄存器）。

该同步升压模块可通过硬件或软件控制模式强制关闭。软件控制模式下，位于寄存器0x09。硬件控制模式下，ENB高电平为自适应升压开启，ENB低电平为升压关闭。

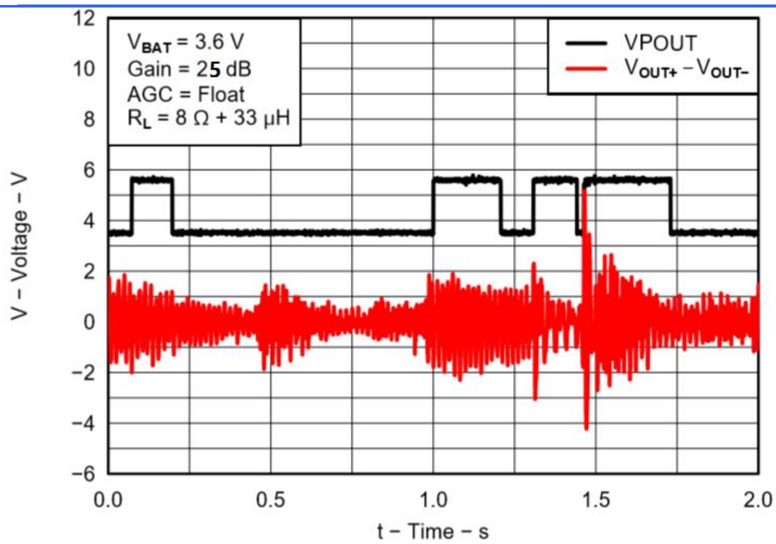


Fig. 8 Adaptive Boost Converter with Typical Music Playback

上图显示的是播放音乐时，输出信号和V_{POUT}的变化关系。

2.2.2 元器件参数选择

(1)BOOST输入输出电容C_{IN}, C_{OUT}

由于输入电压V_{BAT}经BOOST升压后的V_{POUT}直接供电给音频功放，而音频功放在工作时对电源本身具有较大扰动，这时，电源端的滤波就非常重要。

我们建议，在V_{BAT}和V_{POUT}端至少放置一组1uF和10uF接地电容，用于吸收纹波和稳定电压，并尽可能靠近芯片引脚。另外，V_{BAT}和V_{POUT}端需各放置一个不小于470uF的储能电容。这些电容应以最短的路径连接至安静可靠的地，以有效滤波。

(2)电感的选择和放置

为保证芯片的正常工作，建议使用L≥4.7uH, DCR<1ohm, I_{SAT} ≥ 3.5 A。在输出V_{POUT}较大、使用功率较大、音乐波动较大的情况下，应适当选择L较大的电感。

(3)布线考虑

电源线（V_{BAT}, V_{POUT}, PVDD, 包括电源地回路），SW线，应尽可能使用短、粗、无弯折的引线连接；应特别注意SW端引线，其开关频率会影响EMI；

V_{BAT}和V_{POUT}端C_{IN}, C_{OUT}应尽可能靠近芯片引脚，以保证电压的稳定；

IC的所有地，应尽可能以最短的路径和星形结构连接至稳定可靠的地。

2.3. 过温限幅功能（Thermal Foldback）

HT862内部集成了过温限幅功能，当芯片因环境温度过高、功放过载、系统散热性能不佳等原因引起结温高于过温限幅点（TFB, 150℃，可在寄存器0x1C设置修改）时，功放将以默认值t_A = 1200ms/dB的速率自动减小增益，以减小芯片功率耗散从而降低结温；随着温度的降低，当结温小于过温限幅点TFB时，功放又将以默认值t_R = 2400ms/dB的速率自动增加增益，直到结温到达过温限幅点（TFB）。如此循环。增加或减小的每步增益为0.75dB或0.375dB(默认值)，可通过软件控制模式修改，位于寄存器0x0A。该过程示意图如下。

启动时间/释放时间都能通过软件控制模式设置修改（分别位于0x0B, 0x0C寄存器）。

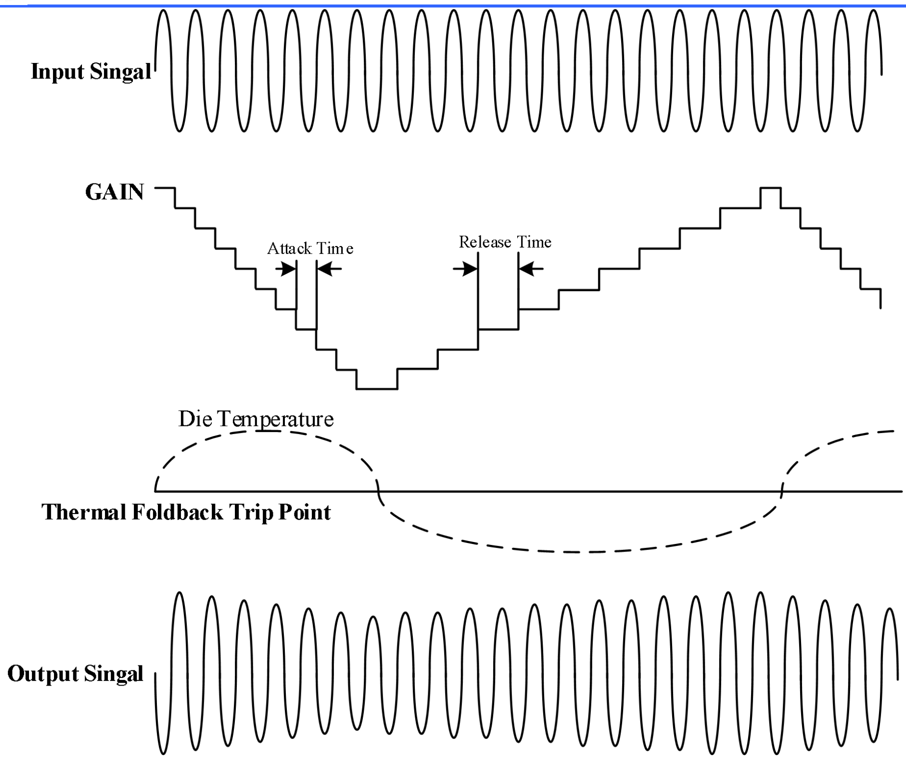


Fig. 9 Thermal Foldback Operation

2.4. 音频功放输入配置

HT862 接受模拟差分或单端音频信号输入，产生 PWM 脉冲输出信号（D 类模式）或音频信号（AB 类模式）驱动扬声器。

对差分输入，通过隔直电容 C_{IN} 分别输入到 IN+和 IN-端。输入 RC 高通滤波器的截止频率 $f_c = 1/(2\pi R_{IN}C_{IN})$。

对单端输入，则通过 C_{IN} 耦合到 IN+端。IN-端必须通过输入电容 C_{IN} 接地。截止频率 f_c 与差分输入时相同。

其中，输入电阻与功放增益的关系如下表。

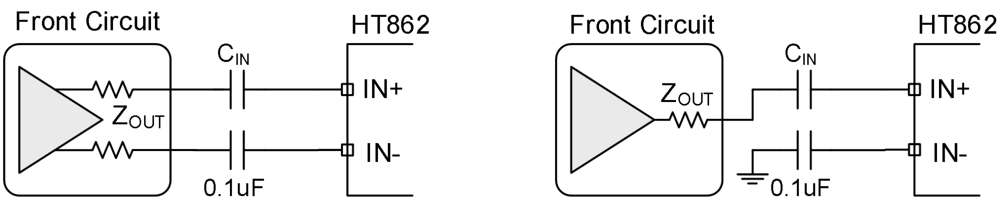


Fig. 10 (1) Differential Input; (1) Single-ended Input

Table. 4 R_{IN} vs GAIN

GAIN	R_{IN}
25dB	31.4 KΩ
30dB	19.1 KΩ

2.5. 音频功放输出

一般而言，输出端可直接连接负载喇叭。如果输出端的输出线较长，或者对EMI的要求较高，则可选择添置铁氧体磁珠或LC滤波器。

另外，如果输入信号幅度较大(≥1.0Vrms)而未开启AGC功能，或DCDC模块输出电压V_{POUT}取值较大，或负载喇叭阻抗较小（≤4Ω）时，有必要适当增大电源端电容（至少470uF以上），并在输出端加入Snubber电路和肖特基二极管（如图11），防止芯片异常。

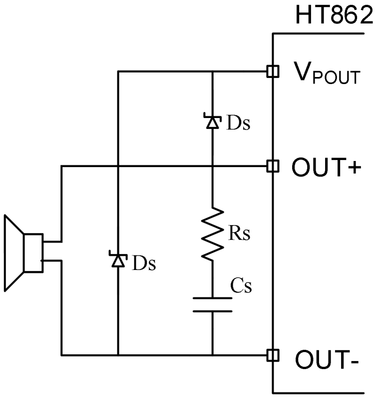


Fig. 11 Amplifier Output Configuration

推荐参数：

Rs: 1.5 ~ 2Ω；

Cs: 330pF~680pF；

Ds: 正向平均电流≥3A；正向浪涌峰值电流≥6A；正向电压（I_F=3A）≤0.5V。

2.6. 保护功能

HT862 具有以下几种保护功能：输出端过流保护、片内过温保护、电源欠压异常保护。

（1）过流保护(Over Current Protection, OCP)

当检测到一输出端对电源、对地、或对另一输出端短路时，过流保护启动，输出端切换至高阻态，防止芯片烧毁损坏。短路情况消除后，通过关断、唤醒一次芯片，或重新上电均能使芯片退出保护模式。该保护电路仅对 Class D 有效。

（2）过温保护(Over Temperature Protection, OTP)

当检测到芯片内温度超过 OTP 时，过温保护启动，正负输出端切换至弱低电平状态（内部通过高阻接地），防止芯片被热击穿损坏。

（3）欠压保护(Low Voltage Malfunction Prevention, LVMP)

当检测到电源端 V_{BAT} 低于 V_{UVLL}，启动欠压保护，D 类功放输出端为弱低电平状态（内部通过高阻接地）；当检测到 V_{BAT} 高于 V_{UVLH}，保护模式自动解除，经启动时间 T_{STUP} 后进入正常工作状态。

3. 控制模式

3.1. 软件控制模式（Software Control Mode）

即 I²C 控制模式。当 ABD、ENB 和 ENA 都接地，HT862 进入 I²C 控制模式，I²C 接口打开，AGC/SDA 为 I²C 数据端口，GAIN/SCL 为 I²C 时钟端口。

HT862 的 I²C 地址是 0x31(00110001)(读)和 0x30(00110000)(写)。ENB 和 ENA 接地后，I²C 接口打开，HT862 为关断状态。在使用 I²C 配置芯片前，需先唤醒芯片，即 0x09 寄存器的 Bit7（ENB）、Bit6(ENA)至少一个写为 1，将 HT862 退出关断模式。

I²C 读写时序如下。相关寄存器说明见第 4 小节。

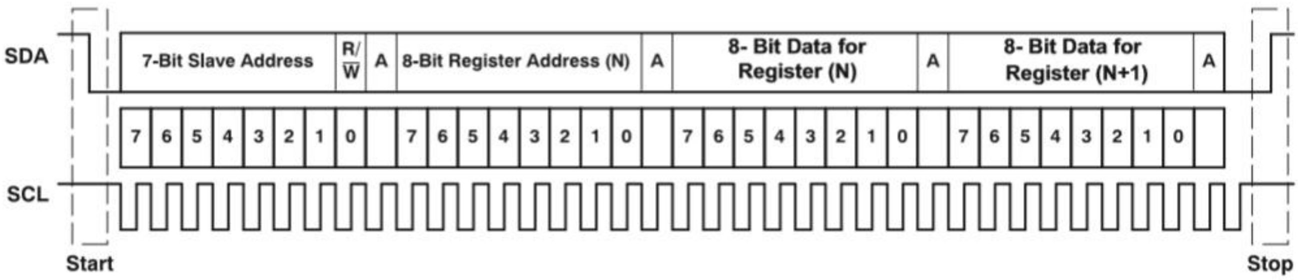


Fig. 12 Typical I²C Sequence

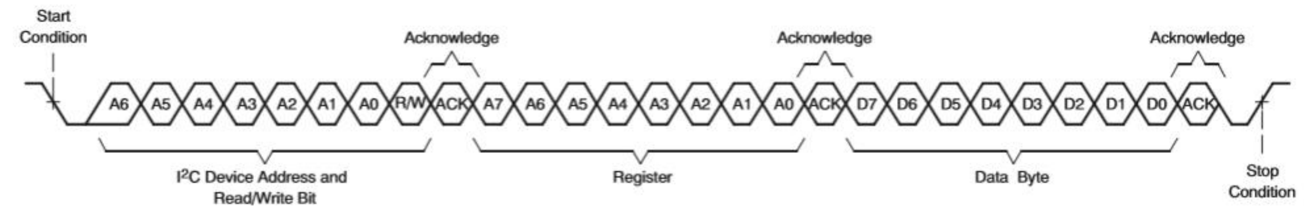


Fig. 13 Single-Byte Write Transfer

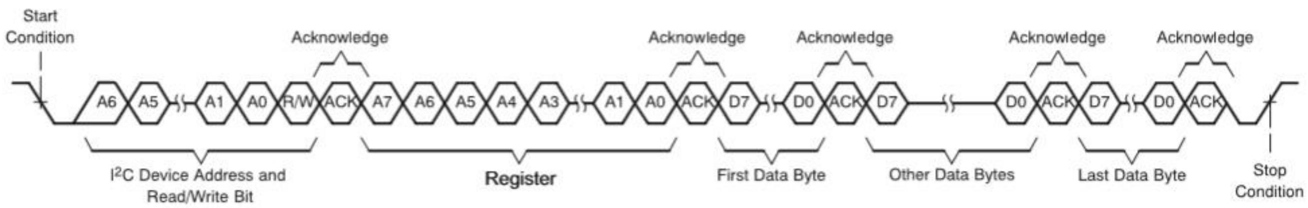


Fig. 14 Multiple-Byte Write Transfer

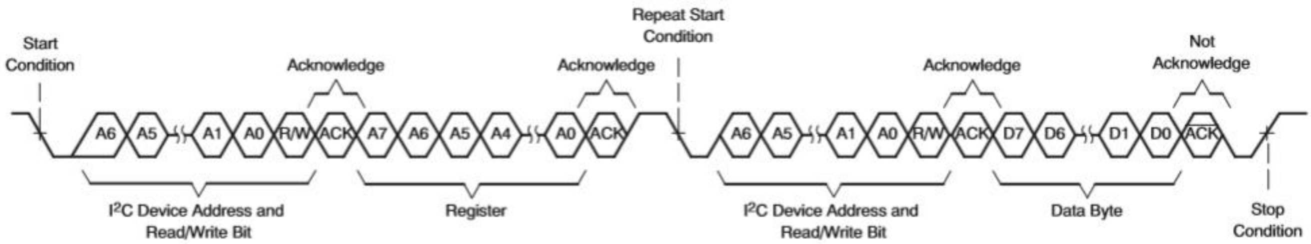


Fig. 15 Single-Byte Read Transfer

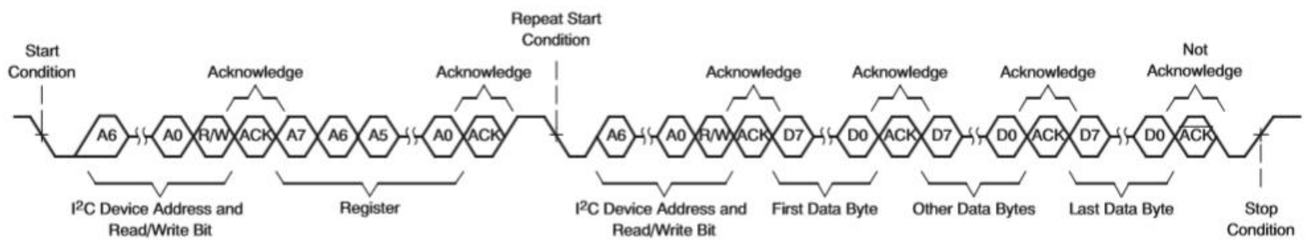


Fig. 16 Multiple-Byte Read Transfer

3.2. 硬件控制模式（Hardware Control Mode）

当 ENA 和 ENB 任一引脚为高电平时，芯片进入硬件控制模式，芯片相关状态通过芯片引脚控制，其他则均为默认状态。

3.2.1 ABD模式切换（ABD）

ABD 为高时，HT862 进入 AB 类模式；ABD 为低时，HT862 进入 D 类模式。需要注意的是，ABD 内部有 1 个 300kΩ的下拉电阻到地。

3.2.2 工作模式控制（ENA, ENB）

通过 ENA, ENB 引脚的设置，芯片可进入相关模式状态如下表所示。

Table. 5 ENA, ENB Terminal Configuration

ENA	ENB	Mode	
H	H	Hardware Control Mode	Adaptive Boost +Audio Amplifier
H	L		Audio Amplifier On, Boost disabled
L	H		Boost On, Audio Amplifier disabled
L	L	Shutdown	

需要注意的是，ENA、ENB 内部各有 1 个 300kΩ的下拉电阻到地。

3.2.3 电池跟踪功能设置（AGC/SDA）

在软件控制模式下，该引脚复用为数据端口 SDA。硬件控制模式下，该引脚可控制选择电池跟踪功能的开关以及电池跟踪拐点。

当 AGC 引脚悬空时，电池跟踪功能关闭；当 AGC 引脚接不同电阻到地时，则电池跟踪功能开启，并选择不同的电池跟踪拐点。具体设置已在上文表 2 中说明，这里再重新列出：

Function	Resistor on AGC pin to GND	Battery tracking point
Battery tracking disabled	Floating	Disabled
Battery tracking point1	33kΩ	3.3V
Battery tracking point2	22kΩ	3.5V
Battery tracking point3	12kΩ	3.8V

3.2.4 增益和静音控制（GAIN/SCL）

在软件控制模式下，该引脚复用为时钟端口 SCL。硬件控制模式下，该引脚可控制选择功放的增益，或进入静音状态。

Table. 6 GAIN Terminal Configuration

GAIN	Mode	R_{IN}
H	Audio Amplifier Mute	/
Floating	Audio Amplifier Gain = 25dB	31.4KΩ
L	Audio Amplifier Gain = 30dB	19.1 KΩ

3.2.5 升压值设置（BST）

硬件控制模式下，通过该引脚悬空或接入不同电阻到地，可选择不同的升压值，具体设置已在上文表 3 中说明，这里再重新列出：

Resistor on BST pin to GND	V_{POUT}
Floating	5.5V
33kΩ	6.5V
22kΩ	7.5V
12kΩ	8.0V

3.2.6 AGC限幅值设置（LIM）

在硬件控制模式下，通过设置LIM引脚的电压，即能控制AGC的开关并设置AGC限幅值。LIM引脚内部电路已在前文图2中表示。LIM引脚直接接地，AGC功能关闭。LIM引脚悬空或通过在LIM引脚加上拉电阻R_H或下拉电阻R_L到V_{POUT}实现不同的AGC限幅值(Limiter Level)。限幅值$V_{LM_L\,(Peak)} = (0.5V_{POUT} - V_{LIM_COM}) \times 5$。典型参数已在上文表1中说明，这里再重新列出：

R_L(Ω)	R_H(Ω)	Limiter level (VRMS)	THD+N(Class D)	THD+N(Class AB)
NC	NC	0.95×V_{POUT}	3%	5%
NC	6M	0.87×V_{POUT}	1%	3%
6M	NC	1.0×V_{POUT}	5%	7%
Short	NC	AGC disabled		

4. 寄存器说明

Register Map

Table. 7 Register Map

<table>
<tr><th>Register</th><th>Bit7</th><th>Bit6</th><th>Bit5</th><th>Bit4</th><th>Bit3</th><th>Bit2</th><th>Bit1</th><th>Bit0</th><th>Default Value</th></tr>
<tr><td>0x00~0x07</td><td colspan="8">Reserved</td><td>00h</td></tr>
<tr><td>0x08</td><td colspan="5">Reserved</td><td>OCP Flag</td><td>OTP Flag</td><td>TFB Flag</td><td>00h</td></tr>
<tr><td>0x09</td><td>ENB</td><td>ENA</td><td colspan="2">Boost Voltage</td><td colspan="2">Battery Tracking Point</td><td colspan="2">Gain</td><td>00h</td></tr>
<tr><td>0x0A</td><td>MUTE</td><td>ABD</td><td>AGC EN</td><td>AGC Step</td><td>TFB</td><td>Adaptive</td><td colspan="2">Modulation Mode</td><td>74h</td></tr>
<tr><td>0x0B</td><td colspan="3">TFB Attack Time</td><td colspan="5">AGC Attack Time</td><td>9Eh</td></tr>
<tr><td>0x0C</td><td colspan="3">TFB Release Time</td><td colspan="5">AGC Release Time</td><td>80h</td></tr>
<tr><td>0x0D</td><td>Unused</td><td colspan="7">Gain1</td><td>30h</td></tr>
<tr><td>0x0E</td><td>Unused</td><td colspan="7">Gain2</td><td>24h</td></tr>
<tr><td>0x0F</td><td>Unused</td><td colspan="7">Gain3</td><td>30h</td></tr>
<tr><td>0x10</td><td colspan="2">Unused</td><td colspan="6">Limiter Level</td><td>3Ch</td></tr>
<tr><td>0x11</td><td colspan="8">Battery Tracking Point3</td><td>BCh</td></tr>
<tr><td>0x12</td><td colspan="8">Battery Tracking Point2</td><td>ADh</td></tr>
<tr><td>0x13</td><td colspan="8">Battery Tracking Point1</td><td>A4h</td></tr>
<tr><td>0x14</td><td>Unused</td><td>Unused</td><td colspan="6">Battery Tracking Slope3</td><td>20h</td></tr>
<tr><td>0x15</td><td>Unused</td><td>Unused</td><td colspan="6">Battery Tracking Slope2</td><td>20h</td></tr>
<tr><td>0x16</td><td>Unused</td><td>Unused</td><td colspan="6">Battery Tracking Slope1</td><td>20h</td></tr>
<tr><td>0x17</td><td colspan="2">Boost On Delay Time</td><td colspan="2">Boost Off Delay Time</td><td colspan="2">Amplifier Start-up Time</td><td colspan="2">PWM Delay Time</td><td>19h</td></tr>
<tr><td>0x18</td><td colspan="8">Reserved</td><td>xx</td></tr>
<tr><td>0x19</td><td colspan="2">Boost on threshold voltage</td><td>Unused</td><td>Unused</td><td>Unused</td><td>Unused</td><td>Unused</td><td>Unused</td><td>40h</td></tr>
<tr><td>0x1A~0x1B</td><td colspan="8">Reserved</td><td>xx</td></tr>
<tr><td>0x1C</td><td>OTP EN</td><td colspan="2">OTP, TFB</td><td colspan="2">Reserved</td><td colspan="3">OTP, TFB</td><td>A4h</td></tr>
</table>

寄存器概览如上表。小于 0x08 和大于 0x1C 的寄存器以及表中保留的寄存器和寄存器位都不应写入任何值，否则可能使芯片进入不可知的状态。

HT862 的 I²C 地址是 0x31(00110001)(读)和 0x30(00110000)(写)，如有其他地址需求，请联系我们。下面将逐个介绍寄存器赋值含义。

Register Address: 0x08

Bit	R/W	Label	Default	Description
7:3	R	Reserved	0	Reserved, do not write.
2	R	OCP Flag	0	changes to a 1 when OCP happened; back to 0 when OCP evacuated
1	R	OTP Flag	0	Changes to a 1 when die temperature is above OTP point; back to 0 when that is below OTP - OTP_{hys}
0	R	TFB Flag	0	Changes to a 1 when die temperature is above TFB point; back to 0 when that is below TFB - TFB_{hys}

Register Address: 0x09

Bit	R/W	Label	Default	Description
7:6	R/W	ENB, ENA	00	Mode Setting: 00: Shutdown mode; 01: Pass through mode, Audio Amplifier only; 10: Boost only; 11: Adaptive boost + Audio Amplifier
5:4	R/W	BST	00	Boost Voltage V_{POUT} Setting: 00: V_{POUT} = 8.0V; 01: V_{POUT} = 7.5V; 10: V_{POUT} = 6.5V;

				11: V_{POUT} = 5.5V.
3:2	R/W	Point	00	Battery Tracking Point Setting: 00: Point3, value of reg 0x11, default = 3.8V; 01: Point2, value of reg 0x12, default = 3.5V; 10: Point1, value of reg 0x13, default = 3.3V; 11: Battery tracking function disabled
1:0	R/W	GAIN	00	Amplifier Gain Setting: 00: Gain2, value of reg 0x0E, default = 25dB; 01: Gain1, value of reg 0x0D, default = 30dB; 10: Gain3, value of reg 0x0F, default = 30dB; 11: Gain2, value of reg 0x0E, default = 25dB

Register Address: 0x0A

Bit	R/W	Label	Default	Description
7	R/W	MUTE	0	0: Amplifier enabled; 1: Amplifier mute
6	R/W	ABD	1	0: Class AB; 1: Class D.
5	R/W	AGC EN	1	0: AGC disabled; 1: AGC enabled
4	R/W	AGC Step	1	0: 40 step, 0.75dB/step; 1: 80 step, 0.375dB/step
3	R/W	TFB	0	0: TFB enabled; 1: TFB disabled
2	R	Reserved	1	Reserved, do not write.
1:0	R/W	Modulation	00	Modulation Mode Setting: 00: 4-state mode; 01: 3-state mode; 10: 3-state mode, OUT+ constantly high in positive sine-wave, not recommended to use this mode. If has to, line LC filter between OUT and speaker

Register Address: 0x0B

Bit	R/W	Label	Default	Description							
7:5	R/W	t_{A_TFB}	100	Thermal Foldback Attack Time Setting							
				000	150ms/dB			**100**	**1200ms/dB**		
				001	300ms/dB			101	1800ms/dB		
				010	450ms/dB			110	2400ms/dB		
				011	600ms/dB			111	4800ms/dB		
4:0	R/W	t_{A_AGC}	11110	AGC Attack Time Setting							
				00000	13.33μs/dB	01000	226.6μs/dB	10000	440.0μs/dB	11000	840.0μs/dB
				00001	39.9μs/dB	01001	253.3μs/dB	10001	466.6μs/dB	11001	900.0μs/dB
				00010	66.6μs/dB	01010	280.0μs/dB	10010	480.0μs/dB	11010	1.2ms/dB
				00011	93.3μs/dB	01011	306.6μs/dB	10011	540.0μs/dB	11011	1.5ms/dB
				00100	120μs/dB	01100	333.3μs/dB	10100	600.0μs/dB	11100	3ms/dB
				00101	146.7μs/dB	01101	360.0μs/dB	10101	660.0μs/dB	11101	6ms/dB
				00110	173.4μs/dB	01110	386.7μs/dB	10110	720.0μs/dB	**11110**	**12ms/dB**
				00111	200.0μs/dB	01111	413.3μs/dB	10111	780.0μs/dB	11111	24ms/dB

Register Address: 0x0C

Bit	R/W	Label	Default	Description			
7:5	R/W	t_{A_TFB}	100	Thermal Foldback Release Time Setting			
				000	300ms/dB	**100**	**2400ms/dB**

				001	600ms/dB			101	3600ms/dB		
				010	900ms/dB			110	4800ms/dB		
				011	1200ms/dB			111	9600ms/dB		
4:0	R/W	t_{A_AGC}	00000	AGC Release Time Setting							
				00000	**150ms/dB**	01000	1350ms/dB	10000	2250ms/dB	11000	5400ms/dB
				00001	300ms/dB	01001	1500ms/dB	10001	2700ms/dB	11001	6000ms/dB
				00010	450ms/dB	01010	1650ms/dB	10010	3000ms/dB	11010	6600ms/dB
				00011	600ms/dB	01011	1800ms/dB	10011	3600ms/dB	11011	7200ms/dB
				00100	750ms/dB	01100	1950ms/dB	10100	3900ms/dB	11100	7800ms/dB
				00101	900ms/dB	01101	2100ms/dB	10101	4200ms/dB	11101	8400ms/dB
				00110	1050ms/dB	01110	2250ms/dB	10110	4500ms/dB	11110	9000ms/dB
				00111	1200ms/dB	01111	2400ms/dB	10111	4800ms/dB	11111	9600ms/dB

Register Address: 0x0D

Bit	R/W	Label	Default	Description
7	R	Unused	0	Unused, make it always 0
6:0	R/W	Gain1	30h	Set gain1, detail followed.

Register Address: 0x0E

Bit	R/W	Label	Default	Description
7	R	Unused	0	Unused, make it always 0
6:0	R/W	Gain2	24h	Set gain2, detail followed.

Register Address: 0x0F

Bit	R/W	Label	Default	Description
7	R	Unused	0	Unused, make it always 0
6:0	R/W	Gain3	30h	Set gain3, detail followed.

修改寄存器 0x0D, 0x0E, 0x0F 的值，即修改了 Gain1，Gain2，Gain3 的值，如此，可实现以下功能：

（1） 改变系统增益；

先赋好 0x0D, 0x0E, 0x0F 的值，随后通过修改 0x09 寄存器的 Bit1:0，改变系统增益。

（2） 音量控制

先通过修改 0x09 寄存器的 Bit1:0 设置好系统增益（如 Gain2），随后通过修改该系统增益对应的寄存器（如 0x0E）进行音量控制。

需要注意的是，增益减小的速率是t_{A_AGC}，增益增大的速率是t_{R_AGC}，在每次改变增益前设置t_{A_AGC}和t_{R_AGC}的值，可实现自定义的音量渐变。音量调节结束后，再将t_{A_AGC}和t_{R_AGC}设置为原始值。

0x0D, 0x0E, 0x0F的值对应增益见下表。

0x0D or 0x0E or 0x0F	Gain1 or Gain2 or Gain3	R_{IN}
0110,0000	0dB	193.4k
0110,0001	0.375dB	190.7k
0110,0010	0.750dB	188.0k
Gain increased by 0.375dB every step		R_{IN} decreased by 2.7k every step
0111,1111	11.625dB	104.3k
0000,0000	12dB	107.0k
0000,0001	12.375dB	109.7k
Gain increased by 0.375dB every step		R_{IN} decreased by 1.9117k every step
0011,0000	30dB	19.85k

Register Address: 0x10

Bit	R/W	Label	Default	Description	
7:6	R	Unused	00	Unused, make it always 0	
5:0	R/W	V_{LIM_L}	3Ch	Limiter Level $V_{LM\_L\,(Peak)}$ Setting:	
				11,1111	Biggest limiter level can be set in I²C mode
				Decreased by $0.0095\times V_{POUT}$ every step	
				11,1100	$V_{LM\_L\,(Peak)} = (V_{POUT}/2 - V_{LIM\_COM})\times 5$, if LIM floating, $V_{LIM\_L(Peak)} = 0.95\times V_{POUT}$
				Decreased by $0.0095\times V_{POUT}$ every step	
				00,0000	Smallest limiter level can be set in I²C mode.

Register Address: 0x11

Bit	R/W	Label	Default	Description
7:0	R/W	Point3	BCh	Set battery tracking point 3, default ≈ 3.8V, can be calculated by: DEC(Reg0x11) ×0.0202

Register Address: 0x12

Bit	R/W	Label	Default	Description
7:0	R/W	Point2	ADh	Set battery tracking point 2, default ≈ 3.5V, can be calculated by: DEC(Reg0x11) ×0.0202

Register Address: 0x13

Bit	R/W	Label	Default	Description
7:0	R/W	Point1	A4h	Set battery tracking point 1, default ≈ 3.3V, can be calculated by: DEC(Reg0x11) ×0.0202

Register Address: 0x14

Bit	R/W	Label	Default	Description
7:6	R	Unused	00	Unused, make it always 0
5:0	R/W	Slope3	20h	Set battery tracking slope3, default ≈ 3V/V, can be calculated by: $3\times(bit5+\frac{1}{2}\times bit4+\frac{1}{4}\times bit3+\frac{1}{8}\times bit2+\frac{1}{16}\times bit1+\frac{1}{32}\times bit0)$

Register Address: 0x15

Bit	R/W	Label	Default	Description
7:6	R	Unused	00	Unused, make it always 0
5:0	R/W	Slope2	20h	Set battery tracking slope2, default ≈ 3V/V, can be calculated by: $3\times(bit5+\frac{1}{2}\times bit4+\frac{1}{4}\times bit3+\frac{1}{8}\times bit2+\frac{1}{16}\times bit1+\frac{1}{32}\times bit0)$

Register Address: 0x16

Bit	R/W	Label	Default	Description
7:6	R	Unused	00	Unused, make it always 0
5:0	R/W	Slope1	20h	Set battery tracking slope1, default ≈ 3V/V, can be calculated by: $3\times(bit5+\frac{1}{2}\times bit4+\frac{1}{4}\times bit3+\frac{1}{8}\times bit2+\frac{1}{16}\times bit1+\frac{1}{32}\times bit0)$

Register Address: 0x17

Bit	R/W	Label	Default	Description
7:6	R/W	t_{BOOST_ON}	00	Boost Converter Start On Time t_{BOOST_ON} Setting: **00: 1.5ms;** 01: 3ms; 10: 6ms; 11: 24ms
5:4	R/W	t_{BOOST_OFF}	01	Boost Converter Shut Off Time t_{BOOST_OFF} Setting::

				00: 57ms; **01: 209ms;** 10: 243ms; 11: 527ms
3:2	R/W	t_{AMP_ON}	10	Audio Amplifier (Class D or Class AB) Start On Time t_{AMP_ON} Setting: 00: 7.5ms; 01: 30ms; **10: 60ms;** 11: 120ms
1:0	R/W	t_{AMP_OFF}	01	PWM Delay Time Setting: 00: 186ns; **01: 0ns, default for 4-state modulation;** 10: 82ns, recommended for 3-state modulation; 11: 15ns

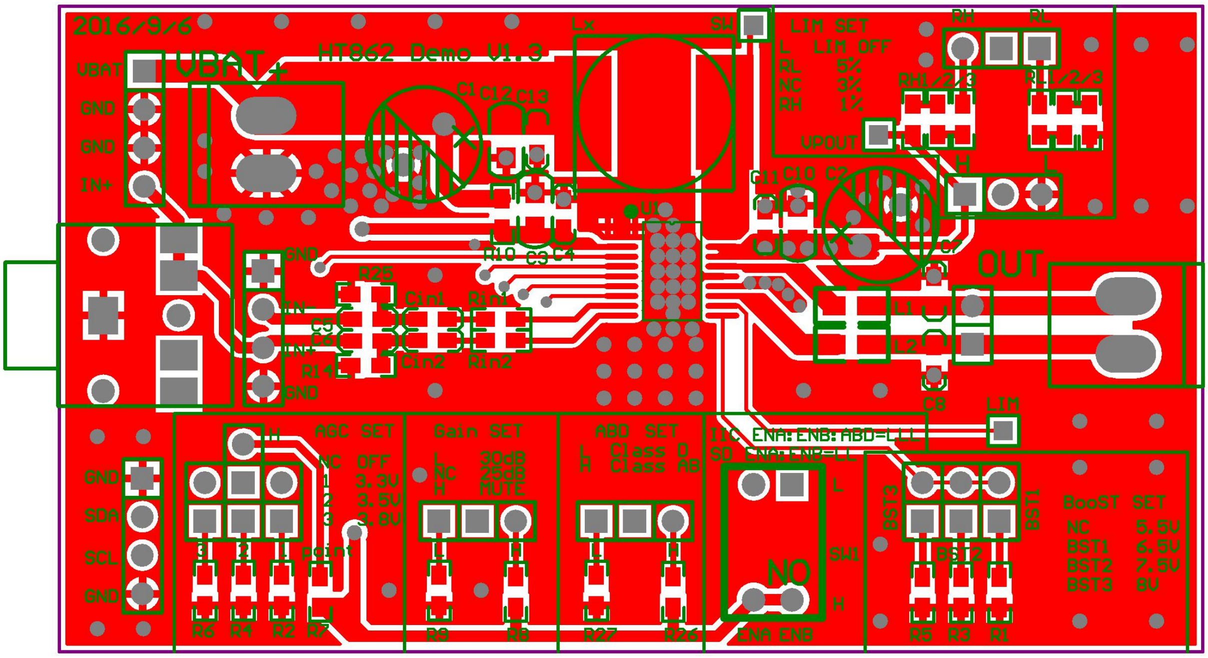
Register Address: 0x19

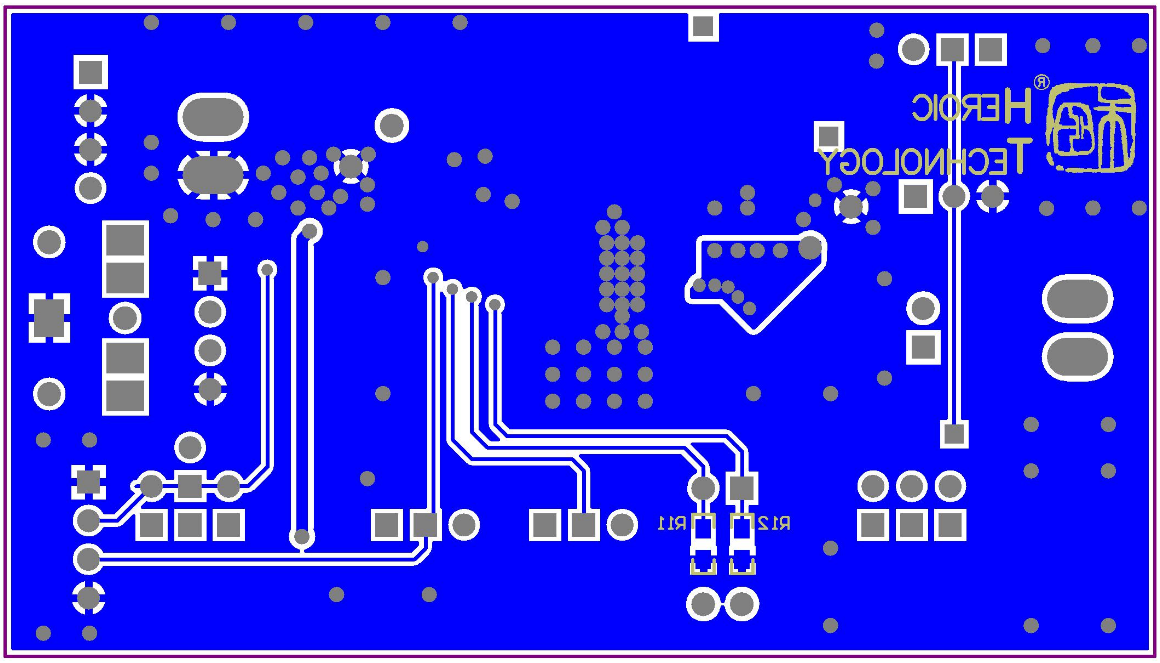
Bit	R/W	Label	Default	Description
7:6	R/W	V_{B_TH}	01	Boost On Threshold Voltage Setting: 00: 0.51V_{BAT}; **01: 0.415V_{BAT};** 10: 1.7V_{RMS}; 11: 1.38 V_{RMS}.
5:0	R	Unused	00,0000	Unused, make it always 0

Register Address: 0x1C

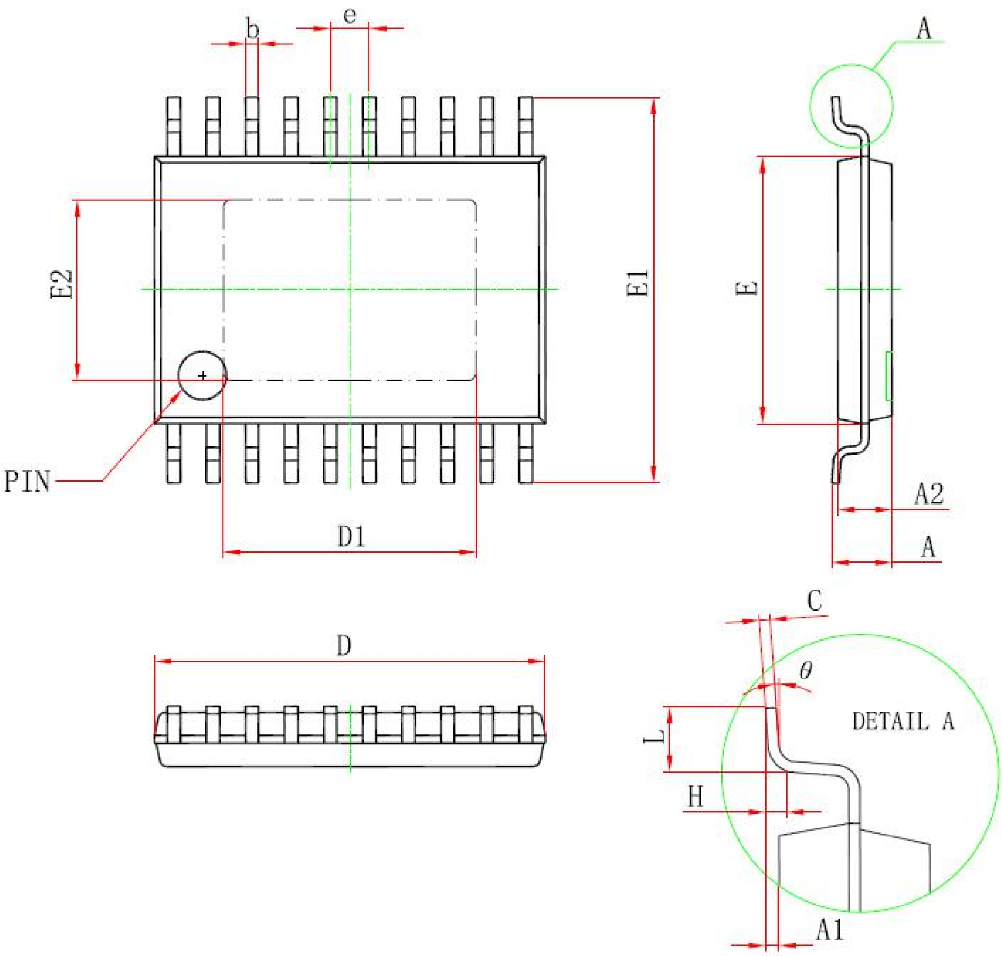
Bit	R/W	Label	Default	Description
7	R/W	OTP EN	1	0: Over temperature protection disabled, may cause permanent damage; **1: Over temperature protection enabled;**
6:5	R/W		01	OTPR reference, TFB reference Setting: 00: TFB = 130℃,OTPR = 115℃; **01: TFB = 150℃,OTPR = 140℃;** 10: TFB = 140℃,OTPR = 130℃; 11: TFB = 160℃,OTPR = 150℃
4:3	R	Reserved	00	Reserved, do not write.
2:0	R/W		100	OTP, TFB, OTPR Setting: 000: OTP = 136℃, TFB = TFB reference -32℃, OTPR = OTPR reference -32℃; 001: OTP = 145℃, TFB = TFB reference -24℃, OTPR = OTPR reference -24℃; 010: OTP = 154℃, TFB = TFB reference -16℃, OTPR = OTPR reference -16℃; 011: OTP = 163℃, TFB = TFB reference -8℃, OTPR = OTPR reference -8℃; **100: OTP = 170℃, TFB = TFB reference, OTPR = OTPR reference;** 101: OTP = 180℃, TFB = TFB reference +10℃, OTPR = OTPR reference+10℃; 110: OTP = 190℃, TFB = TFB reference +20℃, OTPR = OTPR reference+20℃; 111: OTP = 200℃, TFB = TFB reference +30℃, OTPR = OTPR reference+30℃ **DO NOT WRITE OTP OVER 170℃, OR IT MAY CAUSE PERMANENT DAMAGE!!!**

5. PCB Layout


2016/9/6
VBAT+
HT862 Demo V1.3
OUT
AGC SET
Gain SET
ABD SET
BooST SET
LIM SET



■ 封装外形



TSSOP20-PP封装规格

符号	尺寸（mm）		尺寸（inch）	
	最小	最大	最小	最大
D	6.400	6.600	0.252	0.259
D1	4.100	4.500	0.165	0.169
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
E2	2.900	3.100	0.114	0.122
A		1.100		0.043
A2	0.800	1.000	0.031	0.039
A1	0.020	0.150	0.001	0.006
e	0.65(BSC)		0.026(BSC)	
L	0.500	0.700	0.02	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

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